Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Final Report

Study contract no. MOVE/B4/SER/2016-239/S12.762019

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Directorate-General for Mobility and Transport
Directorate B – Investment, Innovative & Sustainable Transport
LIST OF ABBREVIATIONS

ACEA: European Automobile Manufacturers' Association
AFV: Alternative fuelled vehicle
ASTRA: Strategic transport model developed by TRT
BCR: Benefit-cost ratio
C2C-CC: Car2Car Communication Consortium
CAM: Cooperative awareness message
CCAM: Cooperative, connected and automated mobility
CBA: Cost-benefit analysis
CCRW: Cooperative collision risk warning C-ITS service
CEDR: European organisation for national road administrations
CEF: Connecting Europe Facility
CEC: European Committee for Standardization
C-ITS: Cooperative Intelligent Transport Systems
CV: Connected vehicle
DG MOVE: Directorate General for Mobility and Transport
DSRC: Dedicated short-range communication
EBL: Emergency electronic brake light C-ITS service
EVA: Emergency vehicle approaching C-ITS service
ETSI: European Telecommunications Standards Institute
FTE: Full time equivalent
GDP: Gross domestic product
GLOSA / TTG: Green Light Optimal Speed Advisory / Time To Green C-ITS service
GVA: Gross Value Added
HLN: Hazardous location notification C-ITS service
iFuel: Information on fuelling & charging stations for alternatively fuelled vehicles C-ITS service
ISO: International Organization for Standardization
ITS: Intelligent Transport System
ITS-G5: a European set of protocols and parameters for V2V and V2I communications based on the IEEE standard 802.11p on wireless access in vehicular environments
MoU: Memorandum of Understanding
MS: Member State
NHTSA: United States National Highway Traffic Safety Administration
OBU: Onboard unit
OEM: Original equipment manufacturer
P&Ride: Park & Ride information C-ITS service
PInfo: Off street parking information and management C-ITS service
PMang: On street parking management and information C-ITS service
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**POLIS:** European cities and regions network  
**PVD:** Probe vehicle data C-ITS service  
**RSU:** Roadside unit  
**RWW:** Roadworks warning C-ITS service  
**SigV:** Signal violation / Intersection safety warning C-ITS service  
**SmartR:** Traffic information and smart routing C-ITS service  
**SME:** Small and medium-sized enterprises  
**SSV:** Slow or stationary vehicle(s) warning C-ITS service  
**SWD:** Shockwave damping C-ITS service  
**TEN-T:** Trans-European Transport Networks  
**TJW:** Traffic jam ahead warning C-ITS service  
**TMC:** Traffic management centre  
**TRT:** Trasporti e Territorio srl  
**TSP:** Traffic signal priority request by designated vehicles C-ITS service  
**TRUST:** European Transport Network Model developed by TRT  
**US EPA:** United States Environmental Protection Agency  
**V2I:** Vehicle-to-infrastructure  
**V2V:** Vehicle-to-vehicle  
**V2X:** Vehicle-to-X (X represents any entity capable of receiving C-ITS communications)  
**VRU:** Vulnerable Road User (may also refer to the Vulnerable road user protection C-ITS service)  
**VSGN:** In-vehicle signage C-ITS service  
**VSPD:** In-vehicle speed limits C-ITS service  
**WG1:** European Commission DG MOVE C-ITS Platform Working Group 1 – Cost/Benefit Analysis  
**WTC:** Weather conditions warning C-ITS service  
**5GAA:** 5G automotive association
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EXECUTIVE SUMMARY

This ‘Support study for Impact Assessment of Cooperative Intelligent Transport Systems’ reference MOVE/B4/2016-239, was conducted to assist the European Commission in developing a European framework to enhance the widespread deployment of C-ITS services. Cooperative Intelligent Transport Systems (C-ITS) enable vehicles to interact with each other and with the surrounding road infrastructure involving communication between vehicles (vehicle-to-vehicle, V2V), between vehicles and infrastructure (vehicle-to-infrastructure, V2I), infrastructure-to-infrastructure (I2I), and between vehicles and pedestrians or cyclists (vehicle-to-everything, V2X). The benefits of C-ITS span a range of areas, including improving road safety, reducing travel times, optimising transport efficiency, enhancing mobility, increasing service reliability, and reducing energy use and CO₂ and pollutant emissions.

This study chiefly focuses on mature C-ITS services that are expected to be deployed in the short and medium term. The C-ITS services covered in this study are grouped into different bundles:

- Bundle 1: Safety-based V2V services.
- Bundle 2: V2I services that deliver most benefit on motorways.
- Bundle 3: V2I services mostly applicable in urban areas.
- Bundle 4: Services intended to provide information regarding parking (and refuelling) to drivers.
- Bundle 5: Service intended to provide traffic and smart routing information to drivers.
- Bundle 7: V2X vulnerable road user protection service.

General objective

The general objective of the initiative is to establish a clear framework to increase deployment and uptake of C-ITS services across the EU, to significantly improve road safety and traffic efficiency.

Specific objectives

The specific objectives of this initiative are threefold:

- to provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models;
- to reduce barriers and uncertainties to enable large-scale deployment of C-ITS; and
- to ensure interoperability and continuity of C-ITS services across the EU.

Policy options

This study assesses three policy options. The options were created from a long list of policy measures developed using stakeholder input and discussions with the European Commission. The policy measures follow six key themes, and each policy option includes at least one measure in each thematic area. The key themes are directly linked to the root causes of the problem definition developed for the study.

- ‘Privacy and protection of personal data’ measures respond to the challenge of deploying C-ITS in the context of existing legislation;
- ‘Security’ measures ensure the protection of personal data and the authentication of C-ITS messages, enabling provision of the service;
- ‘Interoperability’ measures enable EU-wide interoperability of C-ITS services, increasing the size of the market, the scope for network effects, and the reliable functioning of the services;
‘Compliance assessment’ measures incorporate procedures to ensure adherence to recommended or required specifications for C-ITS services and stations;

‘Continuity’ measures pave the way for continuous C-ITS services across borders; and

‘Enabling conditions’ measures encourage the market for C-ITS services to flourish.

The table below summarises the measures assessed under each policy option, as well as the measures under the study’s baseline.
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<table>
<thead>
<tr>
<th>Privacy and protection of personal data, including access to data and data quality</th>
<th>Security</th>
<th>Interoperability</th>
<th>Compliance assessment</th>
<th>Continuity</th>
<th>Enabling conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement &amp; procedures</td>
<td>Roles/Bodies</td>
<td>Services</td>
<td>Communication specifications</td>
<td>Requirement &amp; procedures</td>
<td>Roles/Bodies</td>
</tr>
</tbody>
</table>

**Baseline: Cross-cutting measures**
- EU policy: ITS Directive, C-ITS Strategy, Connected and automated mobility Strategy
- Regional and national deployment projects e.g. C-Roads
- EU funding in the area e.g. under CEF (including funding / set-up of common EU security elements in 2018-2021)
- Industry deployment of C-ITS

**Baseline: Thematic measures**
- General Data Protection Regulation (GDPR) (includes all the requirements, such as mandatory Data protection impact assessment by data controller)
- ePrivacy Directive and its proposed update
- Available non-binding guidance from the C-ITS platform; in particular the common security & certificate policy
- Available non-binding guidance from C-ITS platform as to the roles/bodies needed (governance framework)
- EU C-ITS Security Credential Management System - Pilot 2018 - 2021 (CEF PSA)
- List of Day 1 and 1.5 services agreed in the C-ITS platform & 2016 EC Strategy
- Existing standards developed by e.g. ETSI/CEN
- Voluntary common service profiles available / being developed (e.g. the Car2Car and C-ROADS profiles)
- ETSI Conformance test specifications
- Existing compliance assessment processes (e.g. for harmonized standards / CE marking)
- Station manufacturers voluntary apply ETSI conformance test specifications
- Ongoing harmonisation & deployment through C-Roads, CAR2CAR and ITS Committee
- Existing MoU C-Roads and C2C-CC
- Work of Amsterdam Group / CODECS / HL Dialogue
- Horizon2020 / 5GAA / EATA work
<table>
<thead>
<tr>
<th>Privacy and protection of personal data, including access to data and data quality</th>
<th>Security</th>
<th>Interoperability</th>
<th>Compliance assessment</th>
<th>Continuity</th>
<th>Enabling conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Requirements &amp; procedures</td>
<td>Roles/ Bodies</td>
<td>Services</td>
<td>Communication specifications</td>
<td>Requirements &amp; procedures</td>
</tr>
<tr>
<td>Policy option 1: Non-binding measures</td>
<td>EC adopts non-binding application guidelines for the GDPR in the context of C-ITS, including responsibilities and requirements.</td>
<td>EC adopts non-binding guidelines on governance structure/ bodies needed for security, recommendations to assign roles to bodies.</td>
<td>EC adopts non-binding guidelines to support the provision of services as defined in the list of Day 1 services.</td>
<td>Reference to existing standards on interoperability and EU-wide service profiles in guidelines. Issue a Mandate to EU level standardisation organisations for standardisation of services beyond the Day 1 list.</td>
<td>EC adopts non-binding guidelines on the compliance assessment process for Day 1 C-ITS services.</td>
</tr>
</tbody>
</table>
## Privacy and protection of personal data, including access to data and data quality

<table>
<thead>
<tr>
<th>Security</th>
<th>Interoperability</th>
<th>Compliance assessment</th>
<th>Continuity</th>
<th>Enabling conditions</th>
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<tbody>
<tr>
<td>Requirement &amp; procedures</td>
<td>Services</td>
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<td>Roles/Bodies</td>
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<td>Roles/Bodies</td>
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### Policy Option 2: Delegate Act

| EC adopts binding application specifications for the GDPR in the context of C-ITS, including the responsibilities and requirements. Establishing purposes for lawfully processing personal data as traffic safety & efficiency, with limitations (no commercial or law enforcement use). Contents of CCMS is put into EU law, specifying C-ITS security requirements & procedures. Possibility to update the CCMS, e.g. through a review clause. | Definition of needed roles in CCMS is put into EU law, plus a requirement to provide information to the Commission on the bodies/authorities in charge, if they have been set up. | Definition of Day 1 services list in specifications. C-ITS stations to be compatible with all Day 1 Services. | Mandate compliance with existing standards on inter-operability in specifications. Mandate compliance with EU-wide service profiles of Day 1 services in specifications. | Define in the specifications, requirements for needed roles in relation to the approval process of C-ITS stations + information to the Commission on the bodies/authorities in charge if they have been set up. |

### Policy Option 3: V2V mandate and legal bodies

| PO2 combined with lawfully processing data based on legal obligation or public interest. | Same as PO2 | Same as PO2 | Same as PO2 | PO2 + Mandatory deployment of V2V communication. | PO2 + |

**Enhanced deployment coordination.**

**Strengthened funding of deployment to enable quicker uptake, including requirements on data reporting and exchange for deployment projects receiving funding.**

**Fund EU deployment coordination after current piloting phase.**
Methods

This impact assessment support study employs a number of tools to estimate the potential impacts of C-ITS policy options:

- Literature and data review: to update the expected impacts of C-ITS services, C-ITS assumptions and other model inputs from the analysis carried out under a prior 2016 study (Ricardo-AEA, 2016).
- Stakeholder engagement: Feedback from the Public Consultation, case study interviews, a stakeholder workshop and other ad hoc interviews.
- Modelling: Pre-processing of assumption data and expected deployment for C-ITS under each scenario, followed by a series of modelling steps centred around the TRT ASTRA, TRT TRUST, and Ricardo CBA models to produce estimates of the indirect impacts of C-ITS.
- Qualitative Assessment: Multi-Criteria Analysis (MCA) has been used to narrow down the long list of policy measures, after which policy options were formulated from the final list. The direct impacts of C-ITS, based on the thematic areas in the problem definition, are assessed qualitatively based on the defined policy measures as well as stakeholder feedback. Some indirect impacts are also assessed qualitatively.

Direct Impacts

Direct impacts, assessed qualitatively for each root cause of the problem definition, are strongest under Policy Option 3, followed closely by Policy Option 2. Policy Option 1 impacts are small, but positive. The direct impacts of the three policy options considered, relative to the baseline, are summarised in the table below for each direct impact:

**Key:**

<table>
<thead>
<tr>
<th>Impact Level</th>
</tr>
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<tbody>
<tr>
<td>Significant positive impact</td>
</tr>
<tr>
<td>Small positive impact</td>
</tr>
<tr>
<td>Negligible/Neutral</td>
</tr>
<tr>
<td>Small negative impact</td>
</tr>
<tr>
<td>Significant negative impact</td>
</tr>
</tbody>
</table>
Table 0-1. Summary of direct impacts relative to the baseline for each Policy Option

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on privacy and protection of personal data</td>
<td>Provision of guidance removing some of the uncertainties, leading to small uptake and deployment increase. Identifying purposes for lawfully processing personal data for traffic safety and efficiency with some impact on removing uncertainties.</td>
<td>Provision of application specifications removing some of the uncertainties, leading to small uptake and deployment increase. Establishment of purposes for lawfully processing personal data for traffic safety and efficiency with significant impact on removing uncertainties.</td>
<td>Lawfully processing data, leading to greater uptake and deployment – helping to create attractive business models.</td>
</tr>
<tr>
<td>Security of C-ITS communications</td>
<td>The non-binding nature of the measures in the recommended CCMS policy limits their effect on security.</td>
<td>Strong measures to reduce deployment barriers related to security by putting CCMS policy into law. It is expected that this approach will have a significant impact on deployment, given the importance of security barriers.</td>
<td>The assignment of legal bodies is likely to ensure the necessary coordination and oversight of security issues, thus ensuring that barriers of C-ITS uptake due to security concerns are reduced to a minimum, leading to the greatest impact on uptake and deployment.</td>
</tr>
<tr>
<td>Impacts on interoperability</td>
<td>More clarity on definition of services and reference to existing standards, however the non-binding nature of the measures limits the impact on interoperability. A mandate for ESO to develop standardisation for services beyond the Day 1 list will ensure that standards are in place for future extensions of the scope beyond Day 1.</td>
<td>Significant positive impact expected on interoperability due to the binding nature of the measures.</td>
<td>Significant positive impact expected on interoperability due to the binding nature of the measures and mandatory deployment through the V2V mandate.</td>
</tr>
<tr>
<td>Impacts on compliance</td>
<td>Small, but limited impact expected due to guidelines providing more clarity on the compliance assessment process and roles and responsibilities.</td>
<td>Positive impacts achieved through specifications around the approvals process, minimum criteria as well as needed roles in relation to the approvals process. Some limitations of effectiveness (with varying uptake across country groups) due to non-binding requirement to set up bodies/authorities in charge.</td>
<td>Strong positive impact (higher than PO2) through assigning roles for compliance assessment to legal bodies as this ensures that compliance is assessed uniformly across Europe.</td>
</tr>
</tbody>
</table>
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on continuity</td>
<td>Some positive impact expected through stakeholder platform, but little direct impact on continuity.</td>
<td>More positive impact on continuity compared to PO1 due to enhanced deployment coordination.</td>
<td>Significantly stronger measure than PO1 and PO2. Mandate on V2V services will be a very effective measure to ensure deployment of C-ITS services across Europe.</td>
</tr>
<tr>
<td>Impacts on enabling conditions</td>
<td>Positive impact on enabling conditions by providing funding for C-ITS development beyond Day 1 and bringing stakeholders together with MoUs.</td>
<td>Strong positive impact by providing funding for deployment projects linked to data reporting and sharing. This knowledge exchange will have a significant positive impact on learning and thus close gaps between Member States. EU deployment coordination beyond the piloting phase will further support this.</td>
<td>Same as PO2</td>
</tr>
</tbody>
</table>
Indirect Impacts

In addition to the direct impacts discussed above, indirect costs and benefits were assessed via the modelling framework. Costs estimated for C-ITS equipment, and the safety, economic, and environmental benefits modelled are shown in Table 0-2. The table also summarises total costs, total benefits, and net benefits for each policy option relative to the baseline. Net benefits, the key quantitative indicator for overall model results, are highest under Policy Option 3. They are more than 1.5 times the net benefits under Policy Option 2. Net benefits under Policy Option 2, while lower than those of Policy Option 3, are still nearly 4 times higher those under Policy Option 1.
### Table 0-2. Summary of modelled impacts for each Policy Option relative to the baseline

<table>
<thead>
<tr>
<th>Impact</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cumulative impact relative to the baseline: 2020-2035</td>
<td>Discounted monetary impact relative to the baseline: 2020-2035</td>
<td>Cumulative impact relative to the baseline: 2020-2035</td>
</tr>
<tr>
<td>New vehicles equipped (vehicles)</td>
<td>16.5 mn</td>
<td>€2.9 bn</td>
<td>79.0 mn</td>
</tr>
<tr>
<td>New vehicles equipped in service by 2035</td>
<td>15.4 mn</td>
<td>-</td>
<td>73.5 mn</td>
</tr>
<tr>
<td>Personal C-ITS devices equipped in service by 2035</td>
<td>19.9 mn</td>
<td>€0.9 bn</td>
<td>63.5 mn</td>
</tr>
<tr>
<td><strong>Total vehicles equipped by 2035</strong></td>
<td><strong>35.3 mn</strong></td>
<td><strong>€3.8 bn</strong></td>
<td><strong>137.0 mn</strong></td>
</tr>
<tr>
<td>Infrastructure upgraded (RSU)</td>
<td>81,000</td>
<td>€0.3 bn</td>
<td>142,000</td>
</tr>
<tr>
<td>New infrastructure deployed (RSU)</td>
<td>13,000</td>
<td>€0.1 bn</td>
<td>134,000</td>
</tr>
<tr>
<td>Central ITS sub-system deployed</td>
<td>370</td>
<td>€0.7 bn</td>
<td>439</td>
</tr>
<tr>
<td><strong>Total infrastructure equipped</strong></td>
<td><strong>94,000</strong></td>
<td><strong>€1.1 bn</strong></td>
<td><strong>276,000</strong></td>
</tr>
<tr>
<td>Total Cost (equipment costs)</td>
<td>n/a</td>
<td>€4.9 bn</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Safety Benefits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatalities avoided</td>
<td>3,700</td>
<td>€4.4 bn</td>
<td>14,100</td>
</tr>
<tr>
<td>Serious Injuries avoided</td>
<td>46,000</td>
<td>€8.0 bn</td>
<td>152,000</td>
</tr>
<tr>
<td>Minor Injuries avoided</td>
<td>199,000</td>
<td>€2.7 bn</td>
<td>700,000</td>
</tr>
<tr>
<td><strong>Total accidents avoided</strong></td>
<td><strong>249,000</strong></td>
<td><strong>€15.0 bn</strong></td>
<td><strong>866,000</strong></td>
</tr>
<tr>
<td><strong>Economic Benefits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel consumption reduced (1000 litres)</td>
<td>4,460</td>
<td>€2.5 bn</td>
<td>20,084</td>
</tr>
<tr>
<td>Urban Travel time savings (million hours)</td>
<td>400</td>
<td>€2.0 bn</td>
<td>2,174</td>
</tr>
<tr>
<td>Impact</td>
<td>Policy Option 1</td>
<td>Policy Option 2</td>
<td>Policy Option 3</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Cumulative impact relative to the baseline: 2020-2035</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Emission reduced (1000 tonnes)</td>
<td>12,000</td>
<td>€0.7 bn</td>
<td>54,000</td>
</tr>
<tr>
<td>PM reduced (tonnes)</td>
<td>44</td>
<td>€0.001 bn</td>
<td>-1,397</td>
</tr>
<tr>
<td>NOX reduced (tonnes)</td>
<td>8,234</td>
<td>€0.1 bn</td>
<td>29,878</td>
</tr>
<tr>
<td>VOC reduced (tonnes)</td>
<td>1,518</td>
<td>€0.002 bn</td>
<td>4,925</td>
</tr>
<tr>
<td>Total environmental benefit</td>
<td>n/a</td>
<td>€0.8 bn</td>
<td>n/a</td>
</tr>
<tr>
<td>Total Benefit</td>
<td>n/a</td>
<td>€20.3 bn</td>
<td>n/a</td>
</tr>
<tr>
<td>Net Benefit</td>
<td>n/a</td>
<td>€15.4 bn</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Environmental Benefits
In addition to the quantified impacts, several qualitative impacts were assessed. These are shown in Table 0-3.

Table 0-3. Summary of indirect impacts assessed qualitatively or outside modelling framework, relative to the baseline

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on vulnerable road users</td>
<td>No VRU-specific C-ITS services. Limited impacts achieved.</td>
<td>PO1 + coordination mechanisms and funding for the development of services beyond day-1 help implementation of VRU C-ITS services.</td>
<td>PO1 + coordination mechanisms and funding for the development of services beyond day-1 help implementation of VRU C-ITS services.</td>
</tr>
<tr>
<td>Impacts on administrative burden for MS and deployment projects</td>
<td>Compliance optional. If administrative burdens too high, Member States and projects would choose not to comply and avoid incurring high costs.</td>
<td>Key compliance costs are adherence to the Certificate and Security Policy and compliance assessment. Costs likely to be very low relative to the equipment costs for infrastructure.</td>
<td>No excess costs beyond those incurred in PO2.</td>
</tr>
<tr>
<td>Public/Private sector split in PV 2020-2035 equipment costs</td>
<td>Most expenditure by private sector (76.9% spend by private sector)</td>
<td>Most expenditure by private sector (86.8% spend by private sector)</td>
<td>Most expenditure by private sector (91.2% spend by private sector)</td>
</tr>
<tr>
<td>Employment impacts by 2035</td>
<td>Increase in EU28 employment relative to baseline (+0.003%)</td>
<td>Increase in EU28 employment relative to baseline (+0.011%)</td>
<td>Increase in EU28 employment relative to baseline (+0.013%)</td>
</tr>
<tr>
<td>R&amp;I impacts by 2035</td>
<td>Limited impact</td>
<td>Increase in R&amp;I activity due to greater policy &amp; regulatory certainty</td>
<td>Increase in R&amp;I activity due to greater policy &amp; regulatory certainty</td>
</tr>
<tr>
<td>Impacts on SMEs</td>
<td>Limited impact</td>
<td>Positive impacts due to greater policy &amp; regulatory certainty</td>
<td>Greatest impact due to policy &amp; regulatory certainty as well as enhanced deployment</td>
</tr>
</tbody>
</table>

Comparison of Options

- **Preferred Option**: The conclusion of this study is that Policy Option 2 is the preferred option, on the basis of superior performance on efficiency, as well as proportionality and subsidiarity. While Policy Option 3 scores best on effectiveness and coherence, the selection of Policy Option 2 does not preclude a future move to Policy Option 3 once the legal and policy avenues are better understood (and the considerations under proportionality and subsidiarity can be updated) and future performance under PO2 is assessed.

- **Effectiveness**: Policy Option 3 is the strongest across nearly all indicators against the three specific objectives defined in our problem tree and the indirect objectives regarding deployment and other indirect benefits.

- **Efficiency**: Policy Option 2 is the most efficient choice. There is a significant leap in the proportion of net benefits between Policy Option 1 and 2 (a 260 percent increase), while there is a lower increase in net benefits between Policy Option 2 and 3 (a 62 percent increase).
• **Coherence**: Policy Option 2 offers stronger performance than Policy Option 1 on coherence. Policy Option 3 performs slightly better than Policy Option 2 with regard to coherence. For this reason, Policy Option 3 is the best choice given the information available.

• **Proportionality and subsidiarity**: Both Policy Option 1 and 2 are proportional – allowing Member States to self-determine the level of deployment they prefer. The enhanced benefits under Policy Option 2 are proportional to the level of control delegated to the EU from Member States. Policy Option 3 imposes a direct obligation on vehicle OEMs, which has costs (both material and political). Given that significant benefits can be achieved already under Policy Option 2 without imposing this obligation, Policy Option 2 is considered more proportional than Policy Option 3.

**Sensitivity Analysis**

The study assessed three sensitivities on all policy options to understand separately the impacts of a 50% increase in equipment costs, a 10% decrease in projected deployment levels, and a 10% decrease in the expected effectiveness of C-ITS services. Overall, cumulative discounted net benefits between 2020 and 2035 remain positive for all policy options under all sensitivities.

Table 0-4 below summarises the results of the equipment cost sensitivity.

**Table 0-4. NPV benefits under policy options when equipment costs rise by 50%**

<table>
<thead>
<tr>
<th></th>
<th>PO1 2020-2030</th>
<th>PO1 2020-2035</th>
<th>PO2 2020-2030</th>
<th>PO2 2020-2035</th>
<th>PO3 2020-2030</th>
<th>PO3 2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV benefits</td>
<td>€5.0 bn</td>
<td>€15.4 bn</td>
<td>€20.4 bn</td>
<td>€59.8 bn</td>
<td>€36.8 bn</td>
<td>€96.5 bn</td>
</tr>
<tr>
<td>NPV benefits after 50% equipment cost increase</td>
<td>€4.0 bn</td>
<td>€13.5 bn</td>
<td>€15.6 bn</td>
<td>€51.5 bn</td>
<td>€27.2 bn</td>
<td>€81.8 bn</td>
</tr>
</tbody>
</table>

The results of the impact of 10% less deployment (deployment sensitivity) and of 10% lower effectiveness of C-ITS services (impact sensitivity) showed a more than proportionate decrease in expected benefits, but still yielded significantly positive net benefits:

- Under Policy Option 1, discounted net cumulative benefits between 2020 and 2035 fall from €15.4 billion to €11.2 billion and €12.6 billion under the deployment and impact sensitivities, respectively.
- For Policy Option 2, discounted net cumulative benefits decrease from €59.8 billion to €43.4 billion and €48.9 billion under the deployment and impact sensitivities.
- Under Policy Option 3, net benefits fall from €96.5 billion to €85.5 billion and €80.7 billion under the deployment and impact sensitivities.
SYNTHÈSE

Cette étude de soutien pour l'évaluation de l'impact des systèmes de transport coopératifs intelligents, référence MOVE / B4 / 2016-239, a été menée pour aider la Commission européenne à développer un cadre européen pour renforcer le déploiement généralisé des services C-ITS. Les systèmes de transport intelligents coopératifs (C-ITS) permettent aux véhicules d'interagir et d'interagir avec l'infrastructure routière environnante; des communications entre véhicules (véhicule à véhicule, V2V), entre véhicules et infrastructure (véhicule à infrastructure, V2I), infrastructure à infrastructure (I2I), et entre véhicules et piétons ou cyclistes (véhicule à tout, V2X). Les avantages des C-ITS couvrent de nombreux domaines, notamment l'amélioration de la sécurité routière, la réduction des temps de parcours, l'optimisation de l'efficacité des transports, la mobilité, la fiabilité des services et la réduction de consommation d'énergie et des émissions de CO₂ et de polluants.

Cette étude se concentre principalement sur les services C-ITS matures qui devraient être déployés à court et à moyen terme. Les services C-ITS couverts dans cette étude sont regroupés en différents groupes:

- Bundle 1: Services V2V basés sur la sécurité.
- Bundle 2: Les services V2I qui offrent le plus d'avantages sur les autoroutes.
- Bundle 3: Services V2I principalement applicables dans les zones urbaines.
- Bundle 4: Services destinés à fournir des informations concernant le stationnement (et le ravitaillement) aux conducteurs.
- Bundle 5: Service destiné à fournir des informations sur le trafic et le routage intelligent aux conducteurs.
- Bundle 7: V2X service de protection des utilisateurs vulnérables.

Objectif général

L'objectif général de l'initiative est d'établir un cadre clair pour accroître le déploiement et l'utilisation des services C-ITS dans l'UE, afin d'améliorer considérablement la sécurité et l'efficacité de la circulation routière.

Objectifs spécifiques

Les objectifs spécifiques de cette initiative sont triples:

- Créer un environnement propice au déploiement pré-commercial et permettre le développement de modèles d’affaires attractifs;
- Réduire les obstacles et les incertitudes pour permettre un déploiement à grande échelle des C-ITS; et
- Assurer l’interopérabilité et la continuité des services C-ITS dans l’UE.

Options politiques

Cette étude évalue trois options politiques. Les options ont été créées à partir d'une longue liste de mesures élaborées à partir des contributions et des discussions des parties prenantes avec la Commission européenne. Les mesures politiques suivent six thèmes principaux et chaque option politique comprend au moins une mesure dans chaque domaine thématique. Les thèmes clés sont directement liés aux causes de la définition du problème développée pour l’étude.

- Les mesures «Protection de la vie privée et protection des données à caractère personnel» répondent au défi du déploiement des C-ITS dans le contexte de la législation existante;
- Les mesures de «Sécurité» garantissent la protection des données personnelles et l’authentification des messages C-ITS, permettant la fourniture du service;
Les mesures «d’Interopérabilité» permettent une interopérabilité à l’échelle de l’UE des services C-ITS, en augmentant la taille du marché, la portée des effets de réseau et le fonctionnement fiable des services;

Les mesures «d’Évaluation de la conformité» intègrent des procédures garantissant le respect des spécifications recommandées ou requises pour les services et les stations C-ITS;

Les mesures de «Continuité» ouvrent la voie à la continuité des services C-ITS au-delà des frontières; et

Les mesures de «Création de conditions favorables» encouragent le développement du marché des services C-ITS.

Le tableau ci-dessous résume les mesures évaluées au titre de chaque option politique, ainsi que les mesures relevant de la base de référence de l’étude.
<table>
<thead>
<tr>
<th>Protection de la vie privée et protection des données à caractère personnel</th>
<th>Sécurité</th>
<th>Interopérabilité</th>
<th>Évaluation de la conformité</th>
<th>Continuité</th>
<th>Création de conditions favorables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exigences et procédures</td>
<td>Responsabilités / Organismes</td>
<td>Services</td>
<td>Spécifications de communication</td>
<td>Exigences et procédures</td>
<td>Responsabilités / Organismes</td>
</tr>
</tbody>
</table>

**Base de référence : Mesures transversales**
- Politique de l'UE : ITS Directive, C-ITS Strategy, Connected and automated mobility Strategy
- Projets de déploiement régionaux et nationaux, par exemple C-Roads
- Financement de l'UE dans ce domaine, par exemple dans le cadre du CEF (y compris le financement / la mise en place d’éléments de sécurité communs de l’UE en 2018-2021)
- Déploiement industriel de C-ITS

**Base de référence : Mesures thématiques**
- Règlement général sur la protection des données (GDPR)
- Directive ePrivacy et sa mise à jour proposée
- Orientation non contraignant disponible de la plate-forme C-ITS ; en particulier la politique commune de sécurité et de certificat
- Orientations non contraignantes disponibles de la plate-forme C-ITS quant aux rôles / organes nécessaires (cadre de gouvernance)
- Système de gestion des informations d’identification de sécurité C-ITS de l’UE - Pilot 2018 - 2021 (PSA CEF)
- Liste des services des jours 1 et 1,5 convenus dans la plateforme C-ITS et la stratégie de la CE pour 2016
- Normes existantes développées par exemple par ETSI / CEN
- Profils de services communs volontaires disponibles / en cours de développement (par exemple les profils Car2Car et C-ROADS)
- Spécifications du test de conformité ETSI
- Processus d’évaluation de la conformité existants (par exemple, normes harmonisées / marquage CE)
- Les fabricants de stations appliquent volontairement les spécifications de test de conformité ETSI
- Harmonisation et déploiement continu via C-Roads, CAR2CAR et le comité ITS
- MoU C-Roads et C2C-CC existants
- Travaux du Groupe d’Amsterdam / Dialogue CODECS / HL Horizon2020 / 5GAA / EATA
<table>
<thead>
<tr>
<th>Protection de la vie privée et protection des données à caractère personnel</th>
<th>Sécurité</th>
<th>Interopérabilité</th>
<th>Évaluation de la conformité</th>
<th>Continuité</th>
<th>Création de conditions favorables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option politique 1: Mesures non contraignantes</strong></td>
<td>EC adopte des lignes directrices d'application non contraignantes pour le GDPR dans le contexte des C-ITS, y compris les responsabilités et les exigences.</td>
<td>EC adopte des lignes directrices non contraignantes, notamment des exigences détaillées sur le contenu des documents de certificat et de politique de sécurité C-ITS européens communs (EU CCMS).</td>
<td>EC adopte des lignes directrices non contraignantes sur la structure / les organes de gouvernance nécessaires à la sécurité, des recommandations pour attribuer des rôles aux organes.</td>
<td>La CE adopte des lignes directrices non contraignantes pour soutenir la fourniture de services telle que définie dans la liste des services Day 1.</td>
<td>Référence aux normes existantes en matière d'interopérabilité et de profils de services à l'échelle de l'UE dans les lignes directrices. Délivrer un mandat aux organisations de normalisation au niveau de l'UE pour la normalisation des services au-delà de la liste Day 1.</td>
</tr>
<tr>
<td>Protection de la vie privée et protection des données à caractère personnel</td>
<td>Sécurité</td>
<td>Interopérabilité</td>
<td>Évaluation de la conformité</td>
<td>Continuité</td>
<td>Création de conditions favorables</td>
</tr>
<tr>
<td>---</td>
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<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Exigences et procédures</td>
<td>Responsabilités / Organismes</td>
<td>Services</td>
<td>Spécifications de communication</td>
<td>Exigences et procédures</td>
<td>Responsabilités / Organismes</td>
</tr>
<tr>
<td><strong>Option politique 2: Acte délégé</strong></td>
<td>EC adopte des spécifications d’application contraignantes pour le GDPR dans le contexte des C-ITS, y compris les responsabilités et les exigences.</td>
<td>Établir des objectifs pour le traitement légal des données personnelles en tant que sécurité et efficacité du trafic, avec des limitations (pas d’utilisation commerciale ou d’application de la loi).</td>
<td>Le contenu du CCMS est inscrit dans la législation de l’UE, spécifiant les exigences et procédures de sécurité C-ITS. Possibilité de mettre à jour le CCMS, par exemple au moyen d’une clause de révision.</td>
<td>La définition des rôles nécessaires dans le CCMS est inscrite dans le droit de l’UE, plus une obligation de fournir des informations à la Commission sur les organes / autorités responsables, s’ils ont été créés.</td>
<td>Définition de la liste des services Day 1 dans les spécifications. Les stations C-ITS doivent être compatibles avec tous les services Day 1. Mise à jour des services et de leurs définitions, par exemple au moyen d’une clause de révision.</td>
</tr>
<tr>
<td>Protection de la vie privée et protection des données à caractère personnel</td>
<td>Sécurité</td>
<td>Interopérabilité</td>
<td>Évaluation de la conformité</td>
<td>Continuité</td>
<td>Création de conditions favorables</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Option politique 3: Mandat et organes juridiques de V2V</strong></td>
<td>Exigences et procédures</td>
<td>Responsabilités / Organismes</td>
<td>Services</td>
<td>Spécifications de communication</td>
<td>Exigences et procédures</td>
</tr>
<tr>
<td>PO2 combiné avec le traitement légal des données basées sur une obligation légale ou d'intérêt public.</td>
<td>Identique à PO2</td>
<td>PO2 + Attribution des rôles à des organes juridiques.</td>
<td>Identique à PO2</td>
<td>Identique à PO2</td>
<td>PO2 + Attribution des rôles à des organes juridiques.</td>
</tr>
</tbody>
</table>
Méthodes
Cette étude d’appui à l’évaluation d’impact utilise un certain nombre d’outils pour estimer les impacts potentiels des options de politique C-ITS:

- Engagement des parties prenantes: rétroaction de la consultation publique, entrevues d’études de cas, atelier avec les parties prenantes et autres entretiens.
- Modélisation: Pré-traitement des données d’hypothèses et déploiement prévu des C-ITS dans chaque scénario, suivi d’une série d’étapes de modélisation centrées sur les modèles TRT ASTRA, TRT TRUST et Ricardo CBA pour produire des estimations des impacts indirects de C-ITS.
- Évaluation qualitative: L’analyse multicritères (MCA) a été utilisée pour affiner la longue liste de mesures, après quoi les options stratégiques ont été formulées à partir de la liste finale. Les impacts directs des C-ITS, basés sur les domaines thématiques de la définition du problème, sont évalués qualitativement sur la base des mesures politiques définies et des commentaires des parties prenantes. Certains impacts indirects sont également évalués qualitativement.

Impacts directs
Les impacts directs, évalués qualitativement pour chaque cause fondamentale de la définition du problème, sont les plus forts dans l’option 3, suivie de près par l’option 2. Les impacts de l’option 1 sont faibles, mais positifs. Les impacts directs des trois options envisagées par rapport à la base de référence sont résumés dans le tableau ci-dessous pour chaque impact direct:

Clé:

<table>
<thead>
<tr>
<th>Impact positif significatif</th>
<th>Petit impact positif</th>
<th>Négligeable / Neutre</th>
<th>Petit impact négatif</th>
<th>Impact négatif significatif</th>
</tr>
</thead>
</table>
### Tableau 0-1. Résumé des impacts directs par rapport à la référence pour chaque option de politique

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Option politique 1</th>
<th>Option politique 2</th>
<th>Option politique 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts sur la vie privée et la protection des données personnelles</td>
<td>Fourniture de lignes directrices supprimant certaines des incertitudes, conduisant à une faible adoption et augmentation du déploiement. Identifier les finalités du traitement légal des données à caractère personnel pour la sécurité du trafic et l'efficacité avec certaines impact sur la suppression des incertitudes.</td>
<td>Fourniture de spécifications d'application supprimant certaines des incertitudes, conduisant à une faible adoption et à une augmentation du déploiement. Établissement d'objectifs pour le traitement licite de données à caractère personnel pour la sécurité et l'efficacité du trafic, avec un impact significatif sur la suppression des incertitudes.</td>
<td>Traitement légal des données, permettant une utilisation et un déploiement accrus, contribuant ainsi à créer des modèles commerciaux attractifs.</td>
</tr>
<tr>
<td>Sécurité des communications C-ITS</td>
<td>Le caractère non contraignant des mesures du CCMS recommandée limite leur effet sur la sécurité.</td>
<td>Des mesures énergiques pour réduire les obstacles au déploiement liés à la sécurité en intégrant le CCMS dans la loi. Cette approche devrait avoir un impact significatif sur le déploiement, compte tenu de l'importance des barrières de sécurité.</td>
<td>L'attribution des organes juridiques assurera probablement la coordination et la surveillance nécessaires des problèmes de sécurité, réduisant ainsi au minimum les obstacles à l'adoption des C-ITS en raison de problèmes de sécurité, ce qui aura un impact majeur sur leur adoption et leur déploiement.</td>
</tr>
<tr>
<td>Impacts sur l'interopérabilité</td>
<td>Plus de clarté sur la définition des services et la référence aux normes existantes, mais Le caractère non contraignant des mesures limite l'impact sur l'interopérabilité. Un mandat de l'ESO pour développer la normalisation des services au-delà de la liste Day 1 garantira la mise en place de normes pour les futures extensions du champ d'application au-delà des services Day 1.</td>
<td>Impact positif significatif attendu sur l'interopérabilité en raison du caractère contraignant des mesures.</td>
<td>Impact positif significatif attendu sur l'interopérabilité en raison du caractère contraignant des mesures et du déploiement obligatoire dans le cadre du mandat V2V.</td>
</tr>
<tr>
<td>Impacts sur la conformité</td>
<td>Impact limité, attendu en raison des directives fournissant plus de clarté sur le processus d'évaluation de la conformité et les rôles et responsabilités.</td>
<td>Impacts positifs obtenus grâce aux spécifications relatives au processus d'approbation, aux critères minimaux et aux rôles nécessaires en rapport avec le processus d'approbation. Certaines limitations de l'efficacité (avec une utilisation variable selon les groupes de...</td>
<td>Impact positif fort (supérieur à PO2) grâce à l'attribution de rôles à l'évaluation de la conformité aux organes juridiques, car cela garantit que la conformité est évaluée de...</td>
</tr>
<tr>
<td>Indicator</td>
<td>Option politique 1</td>
<td>Option politique 2</td>
<td>Option politique 3</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impacts sur la continuité</td>
<td>Un impact positif attendu par le biais de la plate-forme des parties prenantes, mais peu d'impact direct sur la continuité.</td>
<td>Un impact plus positif sur la continuité par rapport au PO1 grâce à une meilleure coordination du déploiement.</td>
<td>Mesure significativement plus forte que PO1 et PO2. Le mandat sur les services V2V constituera une mesure très efficace pour assurer le déploiement des services C-ITS en Europe.</td>
</tr>
<tr>
<td>Impacts sur les conditions favorables</td>
<td>Impact positif sur les conditions favorables en fournissant un financement pour le développement des C-ITS au-delà du Day 1 et en réunissant les parties prenantes avec les protocoles d'accord.</td>
<td>Fort impact positif en fournissant un financement pour des projets de déploiement liés à la communication et au partage de données. Cet échange de connaissances aura un impact positif significatif sur l'apprentissage et réduira ainsi les écarts entre les États membres. La coordination du déploiement de l'UE au-delà de la phase de pilotage le soutiendra davantage.</td>
<td>Identique à PO2</td>
</tr>
</tbody>
</table>
Impacts indirects

En outre des impacts directs évoqués ci-dessus, les coûts et bénéfices indirects ont été évalués via un cadre de modélisation. Les coûts estimés pour l’équipement C-ITS et la sécurité, les avantages économiques et environnementaux modélisés sont présentés dans le tableau 0 - 2. Le tableau résume également les coûts totaux, les bénéfices totaux et les bénéfices nets pour chaque option de politique par rapport à la base de référence. Les bénéfices nets, l'indicateur quantitatif clé des résultats globaux du modèle, sont les plus élevés dans l'option 3. Ils représentent plus de 1,5 fois les bénéfices nets de l'option 2. Les bénéfices nets de l'option 2, bien que inférieurs à ceux de l'option 3, sont encore près de 4 fois supérieurs à ceux de l'option 1.
Tableau 0-2. Résumé des impacts modélisés pour chaque option de politique par rapport à la base de référence

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Option politique 1</td>
<td>16,5 mn</td>
<td>79,0 mn</td>
<td>12,8 md €</td>
<td>133,8 mn</td>
<td>23,6 md €</td>
<td>23,6 md €</td>
</tr>
<tr>
<td>Option politique 2</td>
<td>15,4 mn</td>
<td>73,5 mn</td>
<td>-</td>
<td>125,2 mn</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Option politique 3</td>
<td>19,9 mn</td>
<td>63,5 mn</td>
<td>3,8 md €</td>
<td>16,7 mn</td>
<td>5,9 md €</td>
<td>-</td>
</tr>
<tr>
<td><strong>Impacts sur les coûts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nouveaux véhicules équipés (véhicules)</td>
<td>16,5 mn</td>
<td>79,0 mn</td>
<td>12,8 md €</td>
<td>133,8 mn</td>
<td>23,6 md €</td>
<td>23,6 md €</td>
</tr>
<tr>
<td>Nouveaux véhicules équipés en service par 2035</td>
<td>15,4 mn</td>
<td>73,5 mn</td>
<td>-</td>
<td>125,2 mn</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Appareils personnels ITS équipés par 2035</td>
<td>19,9 mn</td>
<td>63,5 mn</td>
<td>3,8 md €</td>
<td>16,7 mn</td>
<td>5,9 md €</td>
<td>-</td>
</tr>
<tr>
<td>Total des véhicules équipés par 2035</td>
<td>35,3 mn</td>
<td>137,0 mn</td>
<td>16,6 md €</td>
<td>141,9 mn</td>
<td>29,5 md €</td>
<td></td>
</tr>
<tr>
<td>Infrastructure modernisée (RSU)</td>
<td>81,000</td>
<td>142,000</td>
<td>0,5 md €</td>
<td>142,000</td>
<td>0,4 md €</td>
<td></td>
</tr>
<tr>
<td>Nouvelle infrastructure déployée (RSU)</td>
<td>13,000</td>
<td>134,000</td>
<td>1,2 md €</td>
<td>181,000</td>
<td>1,5 md €</td>
<td></td>
</tr>
<tr>
<td>Sous-système ITS central déployé</td>
<td>370</td>
<td>439</td>
<td>0,9 md €</td>
<td>440</td>
<td>0,9 md €</td>
<td></td>
</tr>
<tr>
<td>Infrastructure totale équipée</td>
<td>94,000</td>
<td>276,000</td>
<td>2,5 md €</td>
<td>322,000</td>
<td>2,9 md €</td>
<td></td>
</tr>
<tr>
<td>Coût total (coûts d'équipement)</td>
<td>n/a</td>
<td>4,9 md €</td>
<td>n/a</td>
<td>19,1 md €</td>
<td>n/a</td>
<td>32,3 md €</td>
</tr>
<tr>
<td><strong>Bénéfices de sécurité</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatalités évitées</td>
<td>3,700</td>
<td>14,100</td>
<td>17,0 md €</td>
<td>20,900</td>
<td>25,6 md €</td>
<td></td>
</tr>
<tr>
<td>Blessures graves évitées</td>
<td>46,000</td>
<td>152,000</td>
<td>26,9 md €</td>
<td>209,000</td>
<td>37,6 md €</td>
<td></td>
</tr>
<tr>
<td>Blessures mineures évitées</td>
<td>199,000</td>
<td>700,000</td>
<td>9,5 md €</td>
<td>992,000</td>
<td>13,8 md €</td>
<td></td>
</tr>
<tr>
<td>Total des accidents évités</td>
<td>249,000</td>
<td>866,000</td>
<td>53,4 md €</td>
<td>1,222,000</td>
<td>76,9 md €</td>
<td></td>
</tr>
<tr>
<td><strong>Bénéfices économiques</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Impact de l'Assessment de l'Impact des Systèmes de Transport Intelligents Coopératifs

<table>
<thead>
<tr>
<th>Impact</th>
<th>Option politique 1</th>
<th>Option politique 2</th>
<th>Option politique 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consommation de carburant réduite (1000 litres)</td>
<td>4,460</td>
<td>2,5 md €</td>
<td>20,084</td>
</tr>
<tr>
<td>Économie de temps de déplacement urbain (millions d'heures)</td>
<td>400</td>
<td>2,0 md €</td>
<td>2,174</td>
</tr>
<tr>
<td>Réduction des émissions de CO₂ (1000 tonnes)</td>
<td>12,000</td>
<td>0,7 md €</td>
<td>54,000</td>
</tr>
<tr>
<td>PM réduite (tonnes)</td>
<td>44</td>
<td>0,001 md €</td>
<td>-1,397</td>
</tr>
<tr>
<td>NOX réduit (tonnes)</td>
<td>8,234</td>
<td>0,1 md €</td>
<td>29,878</td>
</tr>
<tr>
<td>COV réduit (tonnes)</td>
<td>1,518</td>
<td>0,002 md €</td>
<td>4,925</td>
</tr>
<tr>
<td><strong>Bénéfices environnemental totaux</strong></td>
<td>n/a</td>
<td>0,8 md €</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Bénéfices totaux</strong></td>
<td>n/a</td>
<td>20,3 md €</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Bénéfices nets</strong></td>
<td>n/a</td>
<td>15,4 md €</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Outre les impacts quantifiés, plusieurs impacts qualitatifs ont été évalués. Celles-ci sont présentées dans le tableau 0 – 3.

**Tableau 0-3. Résumé des impacts indirects évalués qualitativement ou en dehors du cadre de modélisation, par rapport à la base de référence**

<table>
<thead>
<tr>
<th>Indicateur</th>
<th>Option politique 1</th>
<th>Option politique 2</th>
<th>Option politique 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts sur les usagers de la route vulnérables (VRUs)</td>
<td>Aucun VRU - C-ITS services spécifiques. Impacts limités obtenus.</td>
<td>Les mécanismes de coordination du PO1 + et le financement du développement de services au-delà des services Day 1 contribuent à la mise en œuvre des services C-ITS du VRU.</td>
<td>Les mécanismes de coordination du PO1 + et le financement du développement de services au-delà des services Day 1 contribuent à la mise en œuvre des services C-ITS du VRU.</td>
</tr>
<tr>
<td>Impacts sur la charge administrative pour les projets d'états membres et de déploiement</td>
<td>Conformité facultative. Si les charges administratives étaient trop lourdes, les États membres et les projets choisiraient de ne pas se conformer et d’éviter des coûts élevés.</td>
<td>Les principaux coûts de conformité sont le respect de la certification et de la politique de sécurité et l’évaluation de la conformité. Les coûts risquent d’être très faibles par rapport aux coûts d’équipement pour les infrastructures.</td>
<td>Pas de frais supplémentaires en plus de ceux encourus en PO2.</td>
</tr>
<tr>
<td>Part du secteur public / privé dans les coûts d’équipement PV 2020-2035</td>
<td>La plupart des dépenses du secteur privé (76,9% des dépenses du secteur privé)</td>
<td>La plupart des dépenses du secteur privé (86,8% des dépenses du secteur privé)</td>
<td>La plupart des dépenses du secteur privé (91,2% des dépenses du secteur privé)</td>
</tr>
<tr>
<td>Impacts sur l’emploi d’ici 2035</td>
<td>Augmentation de l’emploi dans l’UE28 par rapport à la base de référence (+0,003%)</td>
<td>Augmentation de l’emploi dans l’UE28 par rapport à la base de référence (+0,011%)</td>
<td>Augmentation de l’emploi dans l’UE28 par rapport à la base de référence (+0,013%)</td>
</tr>
<tr>
<td>Impacts de la recherche, l’innovation (R&amp;I) d’ici 2035</td>
<td>Impact limité</td>
<td>Augmentation de l’activité R&amp;I grâce à une plus grande sécurité politique et réglementaire</td>
<td>Augmentation de l’activité R&amp;I grâce à une plus grande sécurité politique et réglementaire</td>
</tr>
<tr>
<td>Impacts sur les PME</td>
<td>Impact limité</td>
<td>Impacts positifs dus à une plus grande sécurité politique et réglementaire</td>
<td>Plus grand impact grâce à la sécurité politique et réglementaire et au déploiement amélioré</td>
</tr>
</tbody>
</table>

**Comparaison des options**

- **Option préférée:** La conclusion de cette étude est que l’option politique 2 est l’option privilégiée, sur la base d’une performance supérieure en termes d’efficacité, ainsi que de proportionnalité et de subsidiarité. Bien que l’option 3 ait la meilleure note d’efficacité et de cohérence, la sélection de l’option 2 n’empêche pas de passer à l’option 3 une fois que les avenues légales et politiques seront mieux comprises (et que les considérations de proportionnalité et de subsidiarité pourront être actualisées) la performance future sous PO2 est évaluée.
• **Efficacité:** L'option politique 3 est la plus forte dans presque tous les indicateurs par rapport aux trois objectifs spécifiques définis dans notre arbre à problèmes et aux objectifs indirects concernant le déploiement et d'autres bénéfices indirects.

• **Efficience:** L'option 2 est le choix le plus efficace. Il y a un bond important dans la proportion des bénéfices nets entre Option 1 et 2 (une augmentation de 260 pour cent), alors qu'il y a une plus faible augmentation des bénéfices nets entre option 2 et 3 (une augmentation de 62 pour cent).

• **Cohérence:** L'option 2 offre une meilleure performance que l'option 1 en matière de cohérence. L'option 3 est légèrement supérieure à l’option 2 en ce qui concerne la cohérence. Pour cette raison, l'option 3 est le meilleur choix compte tenu l’information disponible.

• **Proportionnalité et subsidiarité:** Les deux options politiques 1 et 2 sont proportionnées - permettant aux États membres de déterminer eux-mêmes leur niveau de déploiement. Les avantages accrus de l'option 2 sont proportionnels au niveau de contrôle délégué à l'UE par les États membres. L'option politique 3 impose une obligation directe aux équipementiers automobiles, ce qui entraîne des coûts (à la fois matériels et politiques). Étant donné que des avantages importants peuvent déjà être obtenus dans le cadre de l'option 2 sans imposer cette obligation, l'option 2 est jugée plus proportionnelle que l'option 3.

**Analyse de sensibilité**

L'étude a évalué trois sensibilités sur les options politiques afin de comprendre séparément les effets d’une augmentation de 50% des coûts d'équipement, d'une diminution de 10% des niveaux de déploiement projetés (sensibilité aux déploiement) et d'une diminution de 10% de l’efficacité attendue des services C-ITS (sensibilité aux impacts). Dans l'ensemble, les avantages nets cumulés entre 2020 et 2035 restent positifs pour toutes les options politiques, quelles que soient leurs sensibilités.

Le tableau 0-4 ci-dessous résume les résultats de la sensibilité aux coûts d’équipement.

**Tableau 0-4. Valeur actuelle nette (VAN) au titre des options politiques lorsque les coûts d’équipement augmentent de 50%**

<table>
<thead>
<tr>
<th></th>
<th>PO1 2020-2030</th>
<th>PO1 2020-2035</th>
<th>PO2 2020-2030</th>
<th>PO2 2020-2035</th>
<th>PO3 2020-2030</th>
<th>PO3 2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAN bénéfices</td>
<td>€5.0 bn</td>
<td>€15.4 bn</td>
<td>€20.4 bn</td>
<td>€59.8 bn</td>
<td>€36.8 bn</td>
<td>€96.5 bn</td>
</tr>
<tr>
<td>VAN bénéfices avec augmentation</td>
<td>€4.0 bn</td>
<td>€13.5 bn</td>
<td>€15.6 bn</td>
<td>€51.5 bn</td>
<td>€27.2 bn</td>
<td>€81.8 bn</td>
</tr>
</tbody>
</table>

Les résultats de la sensibilité d’une diminution de 10% des niveaux de déploiement projetés (sensibilité aux déploiement) et d’une diminution de 10% de l’efficacité attendue des services C-ITS (sensibilité aux impacts) ont montré une diminution plus que proportionnelle aux avantages attendus, mais ont néanmoins produit des avantages nets significativement positifs:

• Au titre de l’option politique 1, les avantages cumulés nets actualisés entre 2020 et 2035 passent respectivement de 15,4 milliards d’euros à 11,2 milliards d’euros et 12,6 milliards d’euros au titre des sensibilités de déploiement et d’impact.

• Pour l’option politique 2, les avantages cumulés nets actualisés sont passés de 59,8 milliards d’euros à 43,4 milliards d’euros et de 48,9 milliards d’euros au titre des sensibilités de déploiement et d’impact.
• Dans le cadre de l'option politique 3, les avantages nets passent de 96,5 à 85,5 milliards d'euros et de 80,7 milliards d'euros au titre de la sensibilité au déploiement et à l’impact.
1. **INTRODUCTION**

1.1. **Aim and structure of the study**

This is the final report for the ‘Support study for Impact Assessment of Cooperative Intelligent Transport Systems” reference MOVE/B4/2016-239 (hereafter the ‘project’). The aim of the project was to support the Commission as it seeks to develop the legal framework required to support the widespread deployment of C-ITS services.

This report is submitted by Ricardo, TRT and TEPR, the consultants appointed to conduct this study. The report is structured as follows:

- Problem definition and objectives (see Section 2)
- Definition of baseline (see Section 3)
- Policy measures underlying three policy options and description of the policy options (see Section 4)
- Analysis of impacts (see Section 5), direct impacts and indirect social, economic, and environmental impacts
- A comparison of policy options (see Section 6)
- Sensitivity analysis on the policy options (see Section 7)
- Recommendations for monitoring and evaluation (see Section 8)

These sections are complemented by several detailed methodological annexes in separate documents covering:

- Stakeholder engagement methodology (see Annex A)
- Quantitative modelling methodology (see Annex B)
- Modelling results from two deployment scenarios (see Annex C)
- National and deployment case studies (see Annex D)
- Public Consultation report (see Annex E)
- A list of European C-ITS deployment projects (see Annex F)
- Key model results by Member State (see Annex G)

An overview of the overall methodology is shown below in Figure 1-1.
1.2. Introduction to C-ITS

The increasing volume of road transport in the European Union poses several challenges. Road transport is responsible for the bulk of transport emissions, in terms of greenhouse gases and air pollutants. While there have been improvements in road safety in the EU over the last few decades, this trend has recently slowed down and it is unlikely that the EU will reach the objective of a 50 percent reduction in fatalities between 2010 and 2020. In 2016, there were 25,620 fatalities and 246,000 serious injuries on EU roads, with a large variation in performance between Member States (European Commission,
Finally, congested roads incur huge costs to the EU economy. Coordinated action across a number of fronts is required to tackle these issues and prevent them from having strong negative effects on the European population, economy, environment and climate.

The development of new technologies aimed at improving the efficiency, safety and environmental performance of road transport is playing a significant role in achieving the Commission’s goals in this area. One such emerging field is that of Cooperative Intelligent Transport Systems (C-ITS). C-ITS enable vehicles to interact directly with each other and with the surrounding road infrastructure. In road transport, C-ITS typically involves communication between vehicles (vehicle-to-vehicle, V2V), between vehicles and infrastructure (vehicle-to-infrastructure, V2I) and/or infrastructure-to-infrastructure (I2I), and between vehicles and pedestrians or cyclists (vehicle-to-everything, V2X).

The benefits of C-ITS span a range of areas, including improving road safety, reducing congestion, optimising transport efficiency, enhancing mobility, increasing service reliability, reducing energy use and environmental impacts, and supporting economic development. The deployment of C-ITS is particularly important for road transport, which is still the most commonly used mode for both goods and passenger transport (European Commission, 2016). Rail, water and air transport infrastructure is used by a relatively smaller number of transport operators and managed by dedicated infrastructure managers; road transport, on the other hand, is much more diverse. There are millions of road users, both for passenger and freight transport, that act independently of each other, using an extensive road network. The network itself is varied, consisting of large inter-urban motorways, smaller rural roads and urban networks, each of which is often the responsibility of different public authorities. The diversity of road transport, the number of actors involved, including in the management of the network, underlines the need for policy action to ensure that C-ITS develops and is deployed to its maximum potential.

Over the past decade, there have been remarkable new developments in technologies that facilitate C-ITS; however, these are far from being used at their full potential despite the potential benefits. In recognition of the high potential of C-ITS, the Commission in 2016 took the initiative to develop “A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility” (European Commission, 2016). The objective of the C-ITS Strategy is to facilitate the convergence of investments and regulatory frameworks across the EU, in order to see deployment of mature C-ITS services in 2019 and beyond. This includes the adoption of the appropriate legal framework at the EU level by 2018 to ensure legal certainty for public and private investors. The focus of the work lies on “Day 1” and “Day 1.5” services, C-ITS services that will be deployed in the short and medium term. Day 1 services are considered to be mature in the EU from 2019 and thus ready for quick deployment. Day 1.5 C-ITS services are considered to be mature, but not quite ready for a large-scale deployment due to a lack of full specifications or standards, and so would be deployed in a second phase from 2025 onwards (Ricardo et al, 2016).

The policy options assessed in this report will focus on Day 1 services, while two extra scenarios in the annex incorporate Day 1.5 services into the analysis.

The individual services are grouped into different bundles:

- Bundle 1: Day 1 safety-based V2V services

---

1 The bundle numbering has been kept in line with the (Ricardo, 2016) study. However, bundle 6 (freight zone management services), 8 (Cooperative collision risk warning, Motorcycle approaching indication) and 9 (Wrong way driving) were excluded from the study to align better with the day 1 and day 1.5 services identified in the EU C-ITS strategy.
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

- Bundle 2: Day 1 V2I, services that deliver most benefit on motorways. Some services listed here may also be applicable to other road types
- Bundle 3: Day 1 V2I, services expected to only be applicable in urban areas
- Bundle 4: C-ITS services intended to provide information regarding parking (and refuelling) to drivers
- Bundle 5: C-ITS services intended to provide traffic information to drivers
- Bundle 7: V2X service expected to be post day 1. Main benefits are likely to be seen in urban areas

Table 1-1 gives an overview of the services considered in the Impact Assessment support study and their expected impacts (for further details on the impact assumptions please refer to Annex B). These services are in line with the priority services identified in the Commission’s C-ITS strategy.
Table 1-1. C-ITS services included within this study

<table>
<thead>
<tr>
<th>Service</th>
<th>Bundle</th>
<th>Description</th>
<th>Service Time-frame</th>
<th>V2V/V2I</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency electronic brake light (EBL)</td>
<td>1</td>
<td>Aims to prevent rear end collisions by informing drivers of hard braking vehicles ahead. Drivers will be better prepared to adjust their speed accordingly.</td>
<td>Day 1</td>
<td>V2V</td>
<td>+ +</td>
</tr>
<tr>
<td>Emergency vehicle approaching (EVA)</td>
<td>1</td>
<td>Gives an early warning of approaching emergency vehicles, prior to the siren or light bar being audible or visible. This should allow vehicles extra time to clear the road for emergency vehicles and help to reduce the number of unsafe manoeuvres.</td>
<td>Day 1</td>
<td>V2V</td>
<td>+</td>
</tr>
<tr>
<td>Hazardous location notification (HLN)</td>
<td>1</td>
<td>Gives drivers an advance warning of upcoming hazardous locations in the road. E.g. a sharp bend in the road, steep hill, pothole, obstacle, or slippery road service.</td>
<td>Day 1</td>
<td>V2V</td>
<td>+ +</td>
</tr>
<tr>
<td>Slow or stationary vehicle(s) (SSV)</td>
<td>1</td>
<td>Intended to deliver safety benefits by warning approaching drivers about slow or stationary/broken down vehicle(s) ahead, which may be acting as obstacles in the road. The warning helps to prevent dangerous manoeuvres.</td>
<td>Day 1</td>
<td>V2V</td>
<td>+</td>
</tr>
<tr>
<td>Traffic jam ahead warning (TJW)</td>
<td>1</td>
<td>Provides an alert to the driver on approaching the tail end of a traffic jam at speed. This gives the driver time to react safely to traffic jams by giving them more time to react.</td>
<td>Day 1</td>
<td>V2V</td>
<td>+ +</td>
</tr>
<tr>
<td>In-vehicle signage (VSGN)</td>
<td>2</td>
<td>Informs drivers of relevant road signs in the vehicle’s vicinity, giving advance warning of upcoming hazards and increasing driver awareness.</td>
<td>Day 1</td>
<td>V2I</td>
<td>+</td>
</tr>
</tbody>
</table>

The eSafetyForum Intelligent Infrastructure Working Group estimated a lower bound of a 2% increase in average speed for this service.
<table>
<thead>
<tr>
<th>Service</th>
<th>Bundle</th>
<th>Description</th>
<th>Service Time-frame</th>
<th>V2V/V2I</th>
<th>Safety</th>
<th>Fuel Consumption</th>
<th>Pollutant Emissions</th>
<th>Congestion/Travel time</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-vehicle speed limits (VSPD)</td>
<td>2</td>
<td>Intended to prevent speeding and bring safety benefits by informing drivers of speed limits. Speed limit information may be displayed to the driver continuously, or targeted warnings may be displayed in the vicinity of road signs.</td>
<td>Day 1</td>
<td>V2I</td>
<td>+</td>
<td>+</td>
<td>+ / -³</td>
<td>-⁴</td>
</tr>
<tr>
<td>Probe vehicle data (PVD)</td>
<td>2</td>
<td>The purpose of probe vehicle data is to collect and collate vehicle data, which can then be used for a variety of applications. For example, the data can be used to inform drivers about adverse road or weather conditions.</td>
<td>Day 1</td>
<td>V2I</td>
<td>+</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Road works warning (RWW)</td>
<td>2</td>
<td>Enables road operators to communicate information about road works and restrictions to drivers. This allows drivers to be better prepared for upcoming roadworks and potential obstacles in the road, therefore reducing the probability of collisions.</td>
<td>Day 1</td>
<td>V2I</td>
<td>+</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Shockwave Damping (SWD)</td>
<td>2</td>
<td>Shock wave damping aims to smooth the flow of traffic, by damping traffic shock waves.</td>
<td>Day 1</td>
<td>V2I</td>
<td>+</td>
<td>O</td>
<td>O</td>
<td>O⁵</td>
</tr>
<tr>
<td>Weather conditions (WTC)</td>
<td>2</td>
<td>Aims to increase safety through providing accurate and up-to-date local weather information. Drivers are informed about dangerous weather conditions ahead, especially where the danger is difficult to perceive visually.</td>
<td>Day 1</td>
<td>V2I/V2V</td>
<td>+</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

³ The impact of VSPD varies across pollutants. There is a slight reduction in CO and NOx, a slight increase in VOC and while there is a small reduction in PM on motorways, on other interurban roads there is a significant increase in PM.

⁴ The available evidence shows a reduction in speeds in urban areas.

⁵ In TRT’s ASTRA model, traffic efficiency impacts are only modelled on urban roads. This service is not expected to have an impact on urban roads, therefore the impact on traffic efficiency for the purpose of this study was assumed to be zero.
<table>
<thead>
<tr>
<th>Service</th>
<th>Bundle</th>
<th>Description</th>
<th>Service Time-frame</th>
<th>V2V/ V2I</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Light Optimal Speed Advisory (GLOSA) / Time To Green (TTG)</td>
<td>3</td>
<td>Provides speed advice to drivers approaching traffic lights, reducing the likelihood that they will have to stop at a red light, and reducing the number of sudden acceleration or braking incidents.</td>
<td>Day 1</td>
<td>V2I</td>
<td>+                         +                          +</td>
</tr>
<tr>
<td>Signal violation / Intersection Safety (SigV)</td>
<td>3</td>
<td>The primary objective of this service is to reduce the number and severity of collisions at signalised intersections, by warning drivers of possible red light violations.</td>
<td>Day 1</td>
<td>V2I</td>
<td>+                         +                          0</td>
</tr>
<tr>
<td>Traffic signal priority request by designated vehicles (TSP)</td>
<td>3</td>
<td>Allows drivers of priority vehicles (for example emergency vehicles, public transport, HGVs) to be given priority at signalised junctions.(^6)</td>
<td>Day 1</td>
<td>V2I</td>
<td>0                         +                          +</td>
</tr>
<tr>
<td>Information on fuelling &amp; charging stations for alternative fuel vehicles (iFuel)</td>
<td>4</td>
<td>The objective of this service is to broadcast electric vehicle charging point availability and AFV fuelling point information to relevant vehicles.</td>
<td>Day 1.5</td>
<td>V2I</td>
<td>0                         0                          0</td>
</tr>
<tr>
<td>Off street parking information (Pinfo)</td>
<td>4</td>
<td>Intended to bring efficiency benefits to drivers and help to reduce emissions in urban areas by reducing the time spent ‘cruising’ at low speeds.</td>
<td>Day 1.5</td>
<td>V2I</td>
<td>0                         +                          +</td>
</tr>
<tr>
<td>On street parking management and information (PMang)</td>
<td>4</td>
<td>Intended to bring efficiency benefits to drivers and help to reduce emissions in urban areas by reducing the time spent ‘cruising’ at low speeds.</td>
<td>Day 1.5</td>
<td>V2I</td>
<td>0                         +                          +</td>
</tr>
<tr>
<td>Park &amp; Ride information (P&amp;Ride)</td>
<td>4</td>
<td>Intended to reduce congestion in urban areas and also shift travel from cars to public transport.</td>
<td>Day 1.5</td>
<td>V2I</td>
<td>0                         +                          +</td>
</tr>
<tr>
<td>Traffic information &amp; Smart routing (SmartR)</td>
<td>5</td>
<td>The provision of traffic information and smart routing services to vehicles is intended to</td>
<td>Day 1.5</td>
<td>V2I / V2V</td>
<td>0                         +                          +</td>
</tr>
</tbody>
</table>

\(^6\) Only applied to buses in urban areas
### Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
<thead>
<tr>
<th>Service</th>
<th>Bundle</th>
<th>Description</th>
<th>V2V/V2I Time-frame</th>
<th>V2V/ V2I</th>
<th>Safety</th>
<th>Fuel Consumption</th>
<th>Pollutant Emissions</th>
<th>Congestion / Travel time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vulnerable Road user protection (VrU)</td>
<td>7</td>
<td>Improve traffic efficiency and aid traffic flow management.</td>
<td>Day 1.5</td>
<td>V2X</td>
<td>+</td>
<td>O</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This is a safety focussed service, which is intended to protect vulnerable road users. In this case vulnerable road users are considered to be pedestrians and cyclists only.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The considered C-ITS services are primarily information services to increase cooperative awareness, and do not directly act on the behaviour of the driver or vehicle. Higher-level C-ITS services could introduce direct coordination between vehicles at different levels of automation (e.g. cooperative lane merging). Considering this, the assessment isolates C-ITS for simplification purposes, and automation is not considered in this study as part of the scope of the technology assessed. Looking forward, however, it has to be considered that connectivity, and automation are not only complementary technologies but they reinforce each other, (e.g. automated vehicles can automatically generate data to include in C-ITS messages, and trusted, high quality C-ITS messages could be used to give instructions to automated vehicles) and will over time merge completely.

1.3. Background and policy context

1.3.1. Policy context

This support study will help the Commission develop a proposal for an appropriate legal framework for C-ITS. In the following we present the current policy context for C-ITS.

1.3.1.1. Strategy documents

The Commission’s 2011 Transport White Paper (European Commission - DG MOVE, 2011) sets the framework within which EU transport policy is currently developed. While it did not make an explicit reference to C-ITS, it contained many references to the need to develop intelligent systems more generally and included initiatives that gave an important role to ITS.

By 2016, the Commission’s Low Emission Mobility Strategy (European Commission , 2016) began explicitly mentioning C-ITS and underlining its importance for road transport. It noted that attempts were being made to support the development and deployment of C-ITS, which the Commission would add weight to by developing an appropriate policy framework. This framework appeared towards the end of 2016 when the Commission published the above-mentioned “European strategy on Cooperative Intelligent Transport Systems”. Apart from identifying a need for legislative action, it aims to facilitate investments and coordination across the EU to ensure deployment of mature C-ITS services in 2019 and beyond. The strategy sets out a number of actions in different areas (e.g. continuity, security et.) to be taken forward by various actors, including the Commission, Member States and industry. Furthermore, the strategy identifies 20 priority services, both Day 1 and Day 1.5.

The Commission’s ‘Europe on the Move’ Communication (European Commission, 2017), which was published at the end of May 2017, discusses in depth the role of C-ITS in enabling cooperative, connected and automated mobility. It highlights the need for demonstration projects, the importance of developments in communication technologies, and the relevance of work being undertaken in the context of the Digital Single Market Strategy.

In October 2017 the GEAR 2030 Group, a High-Level Group set up in October 2015 to look at the future of the EU automotive sector, published the GEAR 2030 report (European Commission - DG GROW, 2017), which identifies the need for a shared strategy on automated and connected vehicles. The successful development of these types of vehicles poses a number of challenges and so requires close co-operation at the EU and Member State level to ensure maximum benefit can be taken from large scale testing and research. It will also create a need to develop new rules on data storage.

On 13th March 2018 the European Parliament approved a report from the Committee on Transport and Tourism on the EU Strategy on Cooperative Intelligent Transportation Systems (European Parliament - Committee on Transport and Tourism, 2017). The report calls for an acceleration of mass-scale deployment of Vehicle-to- Everything (V2X) in vehicles and infrastructure in Europe and stresses the need for interoperable and backward compatible V2X technology.
In May 2018, as part of the third mobility package, the Commission adopted an EU strategy for connected and automated mobility, which sets out a common vision for the future development of the sector and ensuring that the EU legal and policy framework on key issues (e.g. road safety and cybersecurity) is ready for the market deployment of new products and services. It also defines supporting actions for development and cross-border deployment of key technologies, services and infrastructure, empowering and benefiting both European citizens and European industry. And it addresses related societal issues, which are likely to be decisive for social acceptance of those new technologies; in particular the protection of personal data, underlying ethical choices linked with development of autonomous systems, clear allocation of liability in case of accidents, and the impacts on jobs and skills.

1.3.1.2. **Legislative framework**

The main legal framework for C-ITS is set by the ITS Directive (Directive 2010/40/EU) and the Commission’s 2008 Action Plan for ITS (European Commission, 2008). Both cover all Intelligent Transport Systems but mention C-ITS as a longer-term consideration, which underlines the way in which C-ITS technologies have developed in the last decade. C-ITS are effectively a subset of ITS, and are defined by ISO, CEN and ETSI as a system “that communicates and shares information between ITS stations to give advice or take actions” in order to deliver improvements to the transport system beyond those that could be achieved by stand-alone ITS. Of the 24 separate actions that were set out in the Commission’s ITS Action Plan, a number aimed to prepare the ground for C-ITS, particularly those actions under Action Area 4 ‘Integration of the vehicle into transport infrastructure’. Actions included the development and evaluation of cooperative systems in order to define a harmonised approach, the definition of specifications for the different types of communication (i.e. V2V, V2I etc.) and the definition of a mandate for the European Standardisation Organisations to enable the development of harmonised standards for C-ITS. The proposal that eventually led to the adoption of the ITS Directive implemented Action 6.1 of the Action Plan by setting out a legal framework for the Europe-wide deployment of ITS. The ITS Directive includes several overarching provisions relevant to C-ITS, including provisions on liability and on the protection of personal data, that were also foreseen in the Action Plan.

The Directive itself identifies four different priority areas for ITS. Within the Directive, C-ITS falls into priority area IV – “Linking the vehicle with the transport infrastructure”. The Annex of the Directive identifies actions under priority area IV such as the definition of necessary measures to further progress the development and implementation of cooperative systems. In contrast to priority areas I and III where a set of Delegated Regulations have been adopted (which were identified as priority actions that should be addressed first), priority area IV does not yet include legislation for C-ITS. The outcome of this study will help the Commission to develop a Delegated Act for C-ITS under the ITS Directive and/or other recommended actions.

Other relevant policies in the context of C-ITS include:

- General Data Protection Regulation (EU) 2016/679 (GDPR) repealing Directive 95/46/EC which provides a comprehensive legal framework concerning personal data. In the context of C-ITS, an analysis is needed of the suitable legal basis for lawfully processing personal data.
- Directive 2002/58/EC ‘concerning the processing of personal data and the protection of privacy in the electronic communication sector’ (and proposed Regulation to appeal the Directive, as set out in COM (2017) 10). In addition to the GDPR the EU also applies sectorial data protection legislation known as the ‘ePrivacy Directive’.

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• Regulation (EC) No 661/2009 ‘concerning type-approval requirements for the
general safety of motor vehicles’.

1.3.2. Other Commission activities

Prior to the publication of the Commission’s C-ITS strategy in 2016, a number of other
actions had been initiated to further the deployment of C-ITS in Europe. These include
setting up the C-ITS Platform in November 2014, and bringing together stakeholders to
discuss, exchange knowledge and cooperate on the deployment of C-ITS in Europe.
Phase I of the C-ITS Platform (2014 – 2016) aimed to develop a shared vision on the
interoperable deployment of C-ITS in the EU. That phase of the platform provided policy
recommendations for the development of a roadmap and a deployment strategy for C-
ITS in the EU and identified potential solutions to some critical cross-cutting issues. The
final report of Phase I was published in January 2016 (European Commission, 2016).
Phase II (2016 – 2017) further developed a shared vision for the interoperable
deployment of Cooperative Intelligent Transport Systems (C-ITS) towards cooperative,
connected and automated mobility (CCAM) in the European Union. This includes making
tangible progress towards the definition of implementation conditions for topics already
discussed during the first phase through different Working Groups (e.g. on Security,
Data Protection, Compliance Assessment and Hybrid Communication). These issues are
essential to the interoperability of C-ITS deployment and thus relevant for the
preparation of Delegated Act(s) on C-ITS. The Phase II report was published in
September 2017 (European Commission, 2017).

Two key deliverables of Phase II are:

• Certificate Policy for Deployment and Operation of European Cooperative
  Intelligent Transport Systems (C-ITS), Release 1, June 2017. This document
  defines the European C-ITS Trust model based on Public Key Infrastructure (PKI).
  It sets out legal and technical requirements for the management of public key
  certificates for C-ITS applications by issuing entities and their usage by end-
  entities in Europe. An update release 1.1 was agreed in June 2018.

• Security Policy & Governance Framework for Deployment and Operation of
  European Cooperative Intelligent Transport Systems (C-ITS), Release 1,
  December 2017. The policy provides a framework for the management of
  information security for the deployment and operation of the European
  Cooperative Intelligent Transport System (C-ITS). It defines how to manage
  information security, including the definition of security policies for individual
  stakeholders and the operation of an information security management system.

Regarding funding, the Commission has also supported research into C-ITS, e.g. under
Horizon 2020, and has facilitated its demonstration and deployment in the Connecting
Europe Facility (CEF). In 2016, Member States and the Commission launched the C-
Roads Platform to link various C-ITS deployment activities (most but not necessarily
supported by CEF funding), share and develop technical specifications and test
interoperability. The Platform is supporting the development of the legal framework for
C-ITS that was foreseen in the Commission’s C-ITS Strategy, in particular through the
development of harmonised specifications for I2V services (latest release 1.1 was agreed
in March 2018, available through the C-ROADS website).

1.3.3. Other activities

Apart from Commission activities, there have been a range of activities carried out by
other actors in the field of C-ITS.

Recognising the need to work together, European Transport Ministers agreed on 14 - 15
April 2016, in the Declaration of Amsterdam, to strengthen cooperation in the field of
automated and connected driving and called on the Commission to (i) develop a shared
European strategy, (ii) to review, and where necessary, adapt the EU regulatory
framework, (iii) to develop a coordinated approach towards research and innovation and (iv) to consider the continuation of the C-ITS Platform for the deployment of interoperable C-ITS in the EU (European Commission - DG GROW, 2017).

Industry efforts on the vehicle manufacturers’ side are coordinated through the Car2Car Communication Consortium, a non-profit, industry-driven organisation initiated by European vehicle manufacturers and supported by equipment suppliers, research organisations and other partners. The consortium’s overall aim is to contribute to the harmonisation of car-to-car communication standards by developing an open European standard for C-ITS and a validation process focusing on V2V systems. Furthermore, the consortium is working on realistic deployment strategies and business models to speed-up market penetration and a roadmap for deployment of C-ITS (for V2V and V2I, in cooperation with C-ROADS). (CAR 2 CAR Communication Consortium & C-Roads Platform, 2017). The latest release of the basic system profile (v.1.2.0) was adopted in September 2017.

Activities of the Amsterdam Group, an alliance between road authorities (European Association of Operators of Toll Road Infrastructures, Conference of European Directors of Roads), cities active in POLIS (Network of European cities and regions) and the Car2Car Communication Consortium. The Amsterdam Group is active in facilitating information exchange, discussion and creation of solutions between the involved stakeholders in the context of C-ITS. Key activities include: facilitation of dialogue between actors, exchange of experience and development of functional specifications for C-ITS services as an input for standardisation.

Other alliances that are active in the C-ITS space are, for example, the European Automotive-Telecom Alliance (EATA). It includes six leading sectoral associations, as well as 37 companies, including telecom operators, vendors, vehicle manufacturers and suppliers for both cars and trucks. The main goal of this Alliance is to promote the wider deployment of connected and automated driving in Europe. Another industry association in the field of C-ITS to mention is the 5G Automotive Association (5GAA), a global association with over 67-member companies from the automotive and information and communications technologies (ICT) industries, which aims to develop end-to-end solutions for future mobility and transportation services.

Member States are also carrying out significant activities. Memoranda of Understanding (MoUs) have been signed by 27 Member States plus Norway and Switzerland to set up cross-border corridors across Europe (European Commission, 2017) (European Commission, 2018), including:

- Metz-Merzig-Luxembourg;
- Rotterdam-Antwerp-Eindhoven;
- the Lisbon-Madrid corridor;
- the E8 'Aurora Borealis' corridor (Norway-Finland);
- the Nordic route between Sweden, Finland and Norway.
- Vigo and Porto
- Evora and Mérida

1.4. **Overview of methodological approach**

In this study, we elaborated on the problem definition for slow and inconsistent C-ITS uptake. The analysis yielded a series of policy measures based on key themes identified in the problem definition, which were assessed using a multi-criteria analysis framework. The retained measures were then organised into three distinct policy options that increase in strength. Once the policy options were defined, they were then translated into deployment assumptions via a mixed process of qualitative and quantitative analysis. This process started from the base of a 2016 Deployment Study completed for
the Commission (Ricardo, 2016). Then literature reviews, case studies (and their associated interviews), additional interviews, a stakeholder workshop, C-ITS Member State expert group meetings, and a public consultation were used to build onto the foundation of the 2016 study to provide additional insights, both qualitative and quantitative in nature.

Once the deployment assumptions were defined, they were assessed both qualitatively and quantitatively. Direct impacts of the policy options, linking back to the problem tree and root causes, were analysed qualitatively. Then, indirect social, economic and environmental impacts of policy options were modelled.

A series of steps were required to produce the modelling outputs for the indirect social economic and environmental impacts of this study. This involved an extensive data collection exercise, pre-processing of assumption data for scenarios, followed by a series of modelling steps centred around the ASTRA, TRUST, and CBA models, as shown in Figure 1-2.

**Figure 1-2: Key steps in producing modelling outputs**

The first module of the pre-processing is a calculation of penetration rates for new vehicles, personal C-ITS devices and infrastructure. These are based on uptake assumptions and stock data. The penetration rates are then combined with impact data for different C-ITS services in the scenario module. The outputs from the scenario module, percentage improvements across the different scenarios and country groupings, are then run through the ASTRA/TRUST modelling framework. The outputs from these two models are then processed and combined into our cost-benefit analysis (CBA) model to produce final outputs for our series of indirect impacts. All monetary impacts in this report are presented in present value (2017) terms, discounted using the social discount rate of 4 percent.

2. **Problem definition**

2.1. **Problem tree**

Based on the Terms of References and with input from desk research, as well as the questions and responses from the Public Consultation (PC) and discussions with the Commission Services, an initial problem tree was developed. That version of the problem tree was discussed in the interviews with case study experts. Overall the interviewees agreed with the structure of the problem tree and felt all the key issues had been reflected. Specific stakeholder input on the different root causes are discussed throughout the following sections for each root cause. The final problem tree is presented in Figure 2-1 on the following page.

The problem definition is roughly structured around the five pillars set out in the Commission’s 2016 strategy on C-ITS (“A European strategy on Cooperative Intelligent Transport Systems” (European Commission, 2016)):

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8 Member States have been grouped into Front Runners, Followers, Planned Adopters. These are an indicator of current ambition in the field of C-ITS and consider the actual and planned scale of deployment across the road network in each Member State. See Annex B – 3.1.2.1 for more details.
1. Security
2. Privacy and protection of personal data
3. Communication technologies and frequencies
4. Interoperability at all levels
5. Compliance assessment

In addition, the Commission has identified the need for:

- Ensuring continuity of services across Europe based on a common definition of C-ITS services to be deployed
- Increased coordination between relevant bodies and authorities, to provide appropriate governance for the interoperable deployment of C-ITS
- The creation of a favourable enabling environment to support development towards Cooperative, Connected and Automated Mobility (CCAM) including the development of attractive business models for C-ITS deployment.

Overall, the problem definition remains closely aligned with that set out in the C-ITS Strategy.

Following the Better Regulation guidelines, the following set of questions was considered when developing the detailed problem definition as presented below:

1. What is the nature of the problem(s)?
2. What is the scale of the problem(s)?
3. Who is affected by the problem(s)?
4. What are the drivers and root causes of the problem(s)?
5. How has the problem developed over time and how is it likely to develop without action?
6. Why does the problem need action at EU level?
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Figure 2-1: Problem tree

Root causes
- Uncertainty about business models and integration in CCAM
- Barriers to establishing the necessary trust with regard to cyber security of C-ITS communications
- Uncertainty on how to comply with rules on privacy and protection of personal data
- Lack of coordination between relevant bodies
- Lack of common definition / priority of C-ITS services
- Incompatible communication technologies and frequency spectrum allocation can hamper the proper functioning of C-ITS
- Uncertainties with regard to minimum requirements for interoperability of C-ITS services
- Uncertainties with regard to minimum requirements for compliance assessment for C-ITS services

Drivers
- Failure to provide an enabling environment for further C-ITS development towards CCAM
- Barriers and uncertainties keep stakeholders from large-scale deployment of C-ITS
- Solutions are deployed in a slow, costly and fragmented manner, hindering interoperability and continuity across the EU

Problem
- Limited deployment and uptake of C-ITS services across the EU

General objectives
- Establish right and clear framework conditions to increase deployment and uptake of C-ITS services across the EU, with the aim to significantly improve road safety and traffic efficiency.

Specific objectives
- Provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models
- Reduce barriers and uncertainties to enable large-scale deployment of C-ITS
- Ensure interoperability and continuity of C-ITS services across the EU

Implications
- Societal, economic and environmental benefits of C-ITS are not achieved to their full potential
- EU falls behind in C-ITS deployment compared to other markets > hampered international competitiveness
- Redundancies and limited harvest of network effects lead to high costs for involved stakeholders

Lack of coordination between relevant bodies
The problem tree shows eight root causes contributing to three key drivers, resulting in the illustrated webbing effect. Given that the right-hand side of the tree will be similar for different root causes we will discuss the logic chain from drivers to specific objectives separately in Section 2.2. Each root cause is then linked to the dominant problem drivers it results in, as part of Section 2.3. Finally, in Section 2.4, we present a high-level discussion of the implications of limited deployment and uptake of C-ITS services across the EU, which is the main problem defined in the problem tree.

2.2. **Problem drivers**

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Problem</th>
<th>General objectives</th>
<th>Specific objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to provide an enabling environment for further C-ITS development towards CCAM</td>
<td>Limited deployment and uptake of C-ITS services across the EU</td>
<td>Establish right and clear framework conditions to increase deployment and uptake of C-ITS services across the EU, with the aim to significantly improve road safety and traffic efficiency.</td>
<td>Provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models.</td>
</tr>
<tr>
<td>Barriers and uncertainties keep stakeholders from large-scale deployment of C-ITS</td>
<td></td>
<td></td>
<td>Reduce barriers and uncertainties to enable large-scale deployment of C-ITS.</td>
</tr>
<tr>
<td>Solutions are deployed in a slow, costly and fragmented manner, hindering interoperability and continuity across the EU</td>
<td></td>
<td></td>
<td>Ensure interoperability and continuity of C-ITS services across the EU.</td>
</tr>
</tbody>
</table>

Industry stakeholders have stated their intention to start full scale deployment of C-ITS enabled vehicles in 2019 (European Commission, 2016), as part of the Amsterdam Declaration. However, the Amsterdam Declaration and the European Strategy on C-ITS both highlight the risk that without an EU level framework, C-ITS deployment and the uptake of C-ITS services will be limited. Three main problem drivers have been identified:

- The failure to provide an enabling environment for further C-ITS deployment towards Cooperative, Connected and Automated Mobility (CCAM). Without the necessary framework to support pre-commercial deployment and an environment that allows the development of attractive business models, C-ITS uptake will be very slow. Network effects that are necessary to access the economic, social and environmental benefits will not be achieved, whilst the key beneficial links with the wider CCAM trend may not be developed.

- Certain barriers (such as the lack of trust with regards to cyber security, data privacy) keep stakeholders from deploying or using C-ITS services, which again limits the deployment across the EU.

- Finally, a continuation of the patchwork of C-ITS services available through a range of pre-commercial deployments across EU Member States would result in a slow, costly and fragmented deployment of C-ITS services which hinders interoperability and continuity. It is crucial that these issues are resolved to ensure a homogenous and efficient transport system in line with Europe’s Roadmap to a Single European Transport Area (European Commission - DG MOVE, 2011). Continuity of service, i.e. the availability of C-ITS services across the EU for end-users, is the most important factor for swift deployment of C-ITS in Europe as highlighted in the European Strategy on C-ITS.
To address the problem and its drivers, the Commission identified a need for establishing clear framework conditions to increase deployment and uptake of C-ITS services across the EU. In turn, it is intended to significantly improve road safety and traffic efficiency, whilst also contributing to transport emissions improvements.

Mirroring each of the problem drivers, three specific objectives were identified with the aim to:

i. Provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models
ii. Reduce barriers and uncertainties to enable large-scale deployment of C-ITS
iii. Ensure interoperability and continuity of C-ITS services across the EU

From these specific objectives, different measures were developed to address the individual root causes. These measures are listed and scored in Section 4.2.

2.3. Root causes

This section presents the individual root causes and describes how each one contributes to the three main problem drivers described above.

2.3.1. Root cause #1: Uncertainty about business models and integration in CCAM

The C-ITS market is not yet a mature market and across the EU, uncertainties exist around how its deployment will develop in the context of the wider emerging market for CCAM. While C-ITS is an important stepping stone towards autonomous vehicles, future C-ITS development is hampered by uncertainties around how C-ITS can be integrated into CCAM. A key concern is the topic of C-ITS communication, with new technologies entering the market, where it is not clear how interoperable, secure and trusted communication will be ensured so all traffic participants will be able to exchange effective C-ITS messages. Without certainty around the quality and availability of C-ITS services the link with CCAM is unclear, this will deter stakeholders from large-scale deployment of C-ITS.

EU intervention is needed to bridge the initial gap for the transition of C-ITS services from the testing phase to large scale commercial deployment, whilst further coordination will be required to ensure that deployment is aligned to ensure compatibility and complementarity with the deployment of connected and automated vehicles. The C-ITS Platform Phase II report identified the need for the European Commission to take enabling actions in order to assist Member States and other stakeholders in implementing C-ITS services and to coordinate this closely with CCAM activities.
Other aspects of providing an enabling environment include ensuring that suitable business models for C-ITS deployment can be developed and C-ITS deployment in the EU accelerated. The cost of C-ITS services is a key issue which must be addressed to ensure public acceptance and widespread deployment. While the cost benefit analysis carried out for the 2016 C-ITS Deployment study (Ricardo, 2016) has shown that the potential benefits of C-ITS strongly outweigh the costs, these benefits will only materialise over time, are largely societal benefits that cannot be easily monetised by institutions or companies, and depend strongly on coordinated and accelerated deployment.

Part of the issue is that a large part of these C-ITS benefits (increased safety, less time spent in traffic, lower fuel consumption) go directly to the users / society at large, while the costs of investment and operation need to be borne upfront by road operators and vehicle manufacturers, while the possibility to pass these costs on to users might be limited given the public nature of (some of) the benefits. As the deployment of C-ITS cannot rely on public funding alone and requires the involvement of stakeholders from different industries and the public sector, a common understanding of business models for deploying C-ITS is needed. It is particularly important to ensure that there is a level playing field that enables the development of attractive business models from a range of potential market actors.

The need for a clearly identified business model was further highlighted during stakeholder interviews. A representative from the C-Roads Platform considered the lack of a common business model for all stakeholders (manufacturers, service providers, authorities, and road operators) as the most important issue preventing C-ITS deployment. They noted that each group involved in deployment has to trust the others to deploy, or risk stranded investments. A representative from C-Roads France also noted that a lack of trust between stakeholders slows deployment, as each stakeholder is waiting for the other to deploy before they invest.

### 2.3.2. Root cause #2: Barriers to establishing the necessary trust with regard to cyber security of C-ITS communications

#### Root causes

- Barriers to establishing the necessary trust with regard to cyber security of C-ITS communications

#### Drivers

- Barriers and uncertainties keep stakeholders from large-scale deployment of C-ITS

As the transport system becomes more and more digitised, it may also become more vulnerable to hacking and cyber-attacks. Secure and trusted communication of messages exchanged between vehicles and infrastructure will therefore be key for a successful deployment of C-ITS services, so users can be sure the message is correct and send by a trusted source. Both operators and users will need to establish trust in the cyber security of C-ITS communications, otherwise it will provide a barrier for large scale-deployment.

The Phase II report of the C-ITS Platform states that cyber security is still a barrier for the deployment of Day 1 C-ITS services in Europe. Without clear rules, adopted at the EU level, the development of security solutions will be fragmented and could put interoperability and the safety of end-users at risk. Action at European level is thus required.

The final report of the first phase of the C-ITS platform included a very detailed analysis of the different options for the implementation of a trust model in Europe to ensure secure and interoperable exchange of C-ITS messages on an EU-wide level. Roles and responsibilities have been identified as well as a number of criteria that need to be met.
As an outcome of this process, Member States and industry representatives consensually agreed on the need for a set of common EU technical and organisational requirements.

This is reflected in the definition of a European Union C-ITS Security Credential Management System (EU CCMS) for C-ITS messages. In the second phase of the C-ITS platform a common vision on how to tackle cyber security was developed. The focus of the work was the formulation and agreement of two important documents to enable secure and interoperable C-ITS Day 1 Service deployment in Europe:

- C-ITS Certificate Policy for Deployment and Operation of European C-ITS, which was published in June 2017. An update release 1.1 was agreed in June 2018.

Developing a common security solution for the deployment and operation of C-ITS in Europe will in turn lay the foundation for stronger security at higher levels of automation (including vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication). Any objectives and measures under this theme should be consistent with other Commission policies – such as the recently adopted Cyber Security Package proposal (European Commission - DG CONNECT, 2017).

For harmonisation at the international level the work carried out under the Harmonisation Task Group (in particular HTG6) is considered in this study, which is a cooperation between the European Commission (EC), the United States Department of Transportation (USDOT), and Transport Certification Australia (TCA) aimed at developing a harmonised policy framework for security solutions within and across borders.

Stakeholders recognised that progress is being made in this area through the various activities of the coordinating groups. The C-Roads Platform representative noted that the Security Policy & Governance Framework mentioned above has laid the foundations for a central authority to handle all the security keys required for C-ITS. Several C-Roads projects are currently using the security framework developed under the C-Roads Germany project.

2.3.3. Root cause #3: Uncertainty on how to comply with rules on privacy and protection of personal data

Data sent in C-ITS messages is minimised and pseudonymised for technical and data protection reasons. Nevertheless, data broadcast by C-ITS services from vehicles often qualifies as personal data - as data can be directly linked to the vehicle identification and indirectly to the identity of the vehicle owner - and is therefore related to an identified or identifiable natural person. The current uncertainty on how to comply with existing rules regarding privacy and protection of personal data may hinder the successful large-scale deployment of cooperative, connected and automated vehicles. The risk of tracking individuals has been recognised as a particular issue that could hamper trust in C-ITS. Stakeholders noted that V2I applications may have less issues in this area, if the data sent to infrastructure provides security by design and does not send personal data.

During phase I of the C-ITS platform it was concluded that broadcasts from and to C-ITS equipped vehicles are personal data and therefore the relevant legal framework, i.e. the General Data Protection Regulation (GDPR - Regulation 2016/679), will apply. In Phase 1, the working group had established that informed consent would be the appropriate legal basis for lawfully processing personal data in the context of C-ITS, however that
analysis was carried out on the basis that the previous Data Protection Directive (Directive 95/46 EC – i.e. the predecessor to the GDPR) applied. In Phase II, the working group analysed the appropriate legal basis in more detail and the document “Processing Personal Data in the Context of C-ITS” was submitted to the representative of the technology subgroup of Article 29 Working Party on the 10th of July 2017 with an opinion received in October 2017 (EC - The Article 29 Working Party, 2017). The working group stated their commitment to align any actions with the implementation of the GDPR. The focus of the analysis was on C-ITS Day 1 use cases in the context of the principles of the processing of personal data in accordance with Article 5 of the GDPR (Principles relating to processing of personal data). The analysis found that there currently is no law that justifies the processing of personal data for C-ITS, but a mix of a contractual obligation between the Data Subject and the Data Controller and between the Data Controllers themselves could be an appropriate legal basis.

Any successful C-ITS deployment must be in compliance with the applicable data protection legal framework to increase trust among end-users. Data protection by design and data protection impact assessments will be of central importance in basic C-ITS system layouts and engineering, especially in the context of the applied communication security scheme. Clear guidance at the EU level will be indispensable to ensure the practical application of the GDPR in the C-ITS context.

Stakeholders noted that the GDPR will require some of the previous work in this area to be rethought. There need to be clear principles on what is considered personal data, especially for safety-related applications where benefits will not be seen unless the data is shared.

### 2.3.4. Root cause #4: Lack of coordination between relevant bodies

<table>
<thead>
<tr>
<th>Root causes</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of coordination between relevant bodies</td>
<td>Failure to provide an enabling environment for further C-ITS development towards CCAM</td>
</tr>
<tr>
<td>Solutions are deployed in a slow, costly and fragmented manner, hindering interoperability and continuity across the EU</td>
<td></td>
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</tbody>
</table>

Due to the cross-cutting nature of C-ITS there is a need for coordination between a wide range of stakeholders, spanning across different transport modes, the public sector and industry, as well as local, regional, national and EU-level actors. C-ITS deployment in the EU is a large transformational process and it is vital to develop an EU-wide harmonised and synchronised implementation plan. To ensure such a harmonised approach, different C-ITS bodies need to be established and coordinated, including for governance, policy and operations.

With technology rapidly evolving and the public and private sector investing substantial amounts into developing and testing C-ITS technologies, there is a risk that, without the right framework at European level, that EU-wide interoperability and continuity will not be achieved on time and solutions will be deployed in a slow, costly and fragmented manner.

The lack of coordination across the EU could also hinder the necessary enabling environment for C-ITS deployment towards CCAM.
Stakeholders noted that the C-Roads Platform has provided some level of coordination and governance regarding deployment activities, but that further coordination is required at the EU level.

2.3.5. **Root cause #5: Lack of common definition/priority of C-ITS services**

<table>
<thead>
<tr>
<th>Root causes</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of common definition / priority of C-ITS services</td>
<td>Barriers and uncertainties keep stakeholders from large-scale deployment of C-ITS</td>
</tr>
<tr>
<td></td>
<td>Solutions are deployed in a slow, costly and fragmented manner, hindering interoperability and continuity across the EU</td>
</tr>
</tbody>
</table>

Work carried out by the C-ITS Platform and via existing deployment projects (e.g. under C-Roads) has shown that there is a need for common definitions for C-ITS services. The technology is new and rapidly evolving and without definitions this would lead to barriers and uncertainties for large-scale deployment. The C-ITS Platform Phase II report highlighted the need for developing common definitions for C-ITS services to support continuity and interoperability of services across the EU. EU-wide common definitions for C-ITS and a distinction between C-ITS and ITS services, as well as definitions for individual services are needed.

On the V2V side the Car2Car Communication Consortium has developed common communication profiles covering the following use cases: Dangerous Situation, Special Vehicle, Traffic Jam, Stationary Vehicle, Adverse Weather and Exchange of Impact Reduction Containers (IRCs) as well as a harmonised system profile for in-vehicle C-ITS stations. The latest version of communication profiles was released in August 2018.

On the V2I side the C-Roads Platform has published harmonised C-ITS specifications for Europe for Day 1 V2I services and harmonised system profiles for Road Side Units (RSUs). The latest profiles were released in June 2018.

In addition to common definitions of services, guidance on prioritisation of C-ITS services would also be beneficial (e.g. focus on Day 1 services, combined deployment of Day 1 services) to ensure the highest benefits for C-ITS deployment are achieved.

The definition of C-ITS services was supported by the stakeholders interviewed, with most indicating that this should include technical profiling to ensure interoperability across the EU. The C-Roads Platform representative suggested that safety-related services could be prioritised to ensure that Member States who decide to deploy C-ITS deploy these first.

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9 Available through the C-ROADS website.
2.3.6. **Root cause #6: Incompatible communication technologies and frequency spectrum allocation can hamper the proper functioning of C-ITS**

### Root causes

- Incompatible communication technologies and frequency spectrum allocation can hamper the proper functioning of C-ITS.

### Drivers

- Barriers and uncertainties keep stakeholders from large-scale deployment of C-ITS.
- Solutions are deployed in a slow, costly and fragmented manner, hindering interoperability and continuity across the EU.

C-ITS messages will be transmitted for a wide range of services, in various transport situations and between different actors. Two main types of technology are relevant for the communications required to enable V2V, V2I and vehicle to everything (V2X) C-ITS services:

- **Short-range communications technologies**, which are most relevant for time-critical V2V and V2X communications. These are mainly safety-based communications that predominantly operate in the dedicated 5 GHz frequency band. The main technology currently available to transmit messages in this frequency range is based on the IEEE 802.11p protocol (known in this instance as ITS-G5) for which standardisation activities have been carried out since 2009 under standardisation mandate M/453. A similar cellular-based communications technology known as LTE\(^{10}\)-V2X is under development and could enter the market in the next few years. This is based on standards built into the latest release from the 3rd Generation Partnership Project (3GPP). Note that because of the need for both these technologies to operate in the dedicated 5 GHz band, there is an issue around possible interference between these two currently incompatible technologies. This creates the need for an EU-wide decision on how to proceed in this area, with the desire for both technologies to co-exist and be interoperable, being technically challenging to achieve. A recently adopted mandate to CEPT (European Conference of Postal and Telecommunications Administrations) includes studying the possibility of extending the upper edge of the ITS frequency band by 20 MHz. This expansion is intended to support efficient spectrum use and segmentation of technologies within the band.

- **Longer-range communications technologies**, which are currently most relevant for less time-critical V2I services given the latency limitations of 3G/4G networks. Long-range communication is typically cellular-based, through the existing 3G/4G (and in the future 5G) networks. Because the cellular technology operates in its own, separate, spectrum in this case, there are no issues due to interference between signals.

The choice of short-range technology will potentially have a significant impact on the C-ITS experience due to the current incompatibility of the technologies in the 5 GHz band (assuming that both technologies are able to comply with minimum latency requirements for safety-critical services), but drivers will increasingly expect to receive all information on traffic and safety conditions seamlessly across Europe. While LTE-V2X is a new technology still under development (with early trials currently under way i.e. in the US and China), ITS-G5 (DSRC\(^{11}\)) has already been tested and evaluated in many field trials.

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\(^{10}\) **LTE** = Long-Term Evolution

\(^{11}\) **DSRC** = Dedicated Short-Range Communication
with many standards already drafted and published, and deployed in Europe, the US and Japan.

With multiple technologies available to carry out short- and long-range communication, as described above, continuity of service can only be achieved through a hybrid communication approach, combining complementary communication technologies where technically feasible. The aim should be that all traffic participants are able to communicate with each other and the infrastructure regardless of the communications technologies in use, and that backwards interoperability with already equipped vehicles and infrastructure is ensured. This is particularly important in the automotive sector, as a typical vehicle has a considerably longer lifetime than electronic consumer devices. A lack of compatible communication technologies and frequency spectrum allocation will hinder large-scale C-ITS deployment as well as interoperability and continuity. To achieve these aims across the EU, guidance or specifications at the EU level will be required.

**Stakeholder feedback**

The respondents to the public consultation for the 2016 EU C-ITS strategy gave widespread support for the hybrid communication approach: indeed, less than 5 percent disagreed with initial deployment based on ETSI ITS-G5, and the vast majority see LTE-V2X or in future 5G cellular communications playing an important role in the long-term (European Commission, 2016). A similar level of support was given for hybrid communication technologies in stakeholder responses to the Commission’s 2017 Public Consultation on the topic. A vehicle and equipment manufacturer called for ‘co-existence concepts’ for ITS-G5 and LTE-V2X to be developed. An ITS service provider noted that a hybrid communication approach was essential, particularly as short-range broadcasting might not be the best technology for all use cases, considering data protection. Some stakeholders had reservations around requiring interoperability between technologies in a hybrid approach. A vehicle manufacturer called for the hybrid communication approach to allow for both Wi-Fi and C-V2X, while noting that interoperability between these was not possible. A vehicle and equipment manufacturer noted that clarifying the role of these two communication technologies was important, as there should not be competing technologies from the first day.

Amongst the stakeholders interviewed for the case studies there was consensus that interoperability is essential for an effective C-ITS system, allowing vehicles to communicate with each other. The interviewees showed strong support for a measure setting technology neutrality of spectrum use. The C-Roads Slovenia representative specifically highlighted the need for flexibility for any technology to be chosen. European C-ITS deployment initiatives, notably all initiatives united in the C-Roads Platform, are aiming to deploy based on this hybrid communication approach in areas where different technologies have the same function (i.e. LTE-V2X and ITS-G5 for short-range communication). A C-Roads Platform position paper on the use of the 5.9 GHz band of the radio frequency spectrum was submitted which underlined that there should be interoperability between ITS-G5 and LTE-V2X and that road authorities should not be forced to equip their roads with two or more competing technologies. Additionally, it stated that the platform’s members were committed to ‘backwards compatibility’ criteria.

Some stakeholders in the Public Consultation, however, particularly highlighted their views on the ongoing debate between ITS G5 and LTE V2X. An association representing telecommunications interests (and a similar response from a private company) noted that no technology should be seen to be the incumbent; instead the outcome that should be focused on was that which was cost-efficient. They believed that such an outcome would be delivered where both LTE V2X and ITS-G5 co-existed in the 5.9 GHz radio spectrum frequency band. Another principle that they considered should be applied was

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12 C-Roads Platform (no date) "Radio frequencies designated for enhanced road safety in Europe - C-Roads position on the usage of the 5.9 GHz band”
proportionality, and so LTE V2X should not be required to be interoperable and backwards compatible with ITS-G5.

A technology supplier, on the other hand, was critical of the ‘push from the cellular industry’ to bring an unproven technology into the same radio spectrum frequency band in which stakeholders were deploying ITS-G5 and was concerned that this would affect the deployment of the latter and so not deliver its potential benefits. A vehicle manufacturer noted that feasibility tests needed to be undertaken of the potential of LTE V2X to co-exist in the 5.9 GHz frequency band, or for it be allocated a new frequency band in order to avoid interference with ITS G5. Position papers were provided by a technology provider setting out the case for ITS-G5, as opposed to LTE V2X, for V2X communications. This underlined that the former was ready to be deployed and argued that, unlike cellular technologies, it was able to address the most challenging V2X use cases. A technology provider submitted two documents that argued that ITS-G5 was the only validated technology on the market capable of being used for C-ITS and that any other technologies operating in the 5.9 GHz band of the radio frequency spectrum should not interfere with each other, be interoperable and be able to co-exist with communications in the 5.8 GHz band.

2.3.7. Root cause #7: Uncertainties with regard to minimum requirements for interoperability of C-ITS services

An integrated transport system relies on the interoperability of its components. That means that systems need to be able to interact with each other, across borders and transport modes, at all levels: infrastructure, data, services, applications and networks. Particularly important is the interoperability of services geographically across Europe and potentially globally but also across different technologies. This requires open, standardised interfaces and consistent end-to-end security features.

Without any minimum requirements of C-ITS services for interoperability at the EU level, deployment will be fragmented with limited interoperability and continuity across the EU.

EU-wide deployment specifications or guidance will help ensure interoperability. To this end, C-ITS deployment initiatives within the EU will be key players in helping to define the technical C-ITS communication profiles needed to ensure the interoperability of Day 1 C-ITS services across the EU. An industry-led approach for ensuring interoperability of V2V communication is the work of the Car2Car Communication Consortium. The C-ROADS platform aims at linking C-ITS deployment activities, and jointly developing and sharing technical specifications for V2I communication, whilst verifying interoperability through cross-site testing.

The creation of technical communications profiles for each technology and for all Day 1 services was recommended by some stakeholders who noted that without clear profiles there will be too much variation in the services deployed in different locations. The full range of definitions of interoperability – between countries, operators, city and rural, technologies, and services - need to be considered to ensure effective C-ITS deployment.
2.3.8. **Root cause #8: Uncertainties with regard to minimum requirements for compliance assessment for C-ITS services**

<table>
<thead>
<tr>
<th>Root causes</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncertainties with regard to minimum requirements for compliance assessment for C-ITS services</td>
<td>Solutions are deployed in a slow, costly and fragmented manner, hindering interoperability and continuity across the EU</td>
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</table>

To ensure a seamless deployment of Day 1 C-ITS services, an effective compliance assessment framework needs to be set up that allows C-ITS services and different types of C-ITS stations to be checked against EU-wide system requirements. To date, in addition to uncertainties on EU-wide system requirements, there are uncertainties with regards to the minimum requirements for compliance assessment for C-ITS services. These limit interoperability and continuity of services across the EU.

The Phase II report highlights the need for a common EU legal and technical framework to implement the proposed roles, requirements and processes. Common minimum requirements are required and in a next step, a full compliance assessment process for Day 1 C-ITS services is also required. The task of the Working Group on Compliance Assessment under phase II of the C-ITS Platform was to define a top-level approach and methodology for testing and validation, with a specific focus on C-ITS stations (e.g., vehicles or infrastructure stations), and on the necessary legal and organisational frameworks for the setup and the operational phases of the C-ITS network. Recommendations included the need for a progressive approach to allow for deployment in a short timeframe and the need for the capability to introduce in the future new services and/or new technologies that are backward compatible with already deployed services. Furthermore, the need for further work on the common definition of roles covering all aspects of C-ITS (in particular, compliance assessment, privacy/data protection, security) and to maintain consistency with other validation frameworks, were highlighted (for more on coordination see Section 2.3.4).

Some progress has been made under the Security Working Group of the C-ITS platform which has discussed the definition of baseline security requirements (e.g., to be coded in a protection profile based on common criteria). Stakeholders provided some suggestions on how compliance assessment could work, covering self-assessment and certification, or a combination of both.

2.4. **Implications of limited deployment and uptake of C-ITS services across the EU**

Each of the root causes discussed in the previous sections have jointly led to and will continue to lead to limited deployment and uptake of C-ITS services across the EU. So far, C-ITS deployment is strongly linked to projects with an uneven coverage across Europe, which we describe in Annex D. Without any further policy action to coordinate C-ITS deployment, we project that there will continue to be limited and inconsistent uptake of C-ITS services across Member States.

The limited uptake we expect in the baseline case will have implications for:

- Societal, economic, and environmental benefits
- The EU’s economic competitiveness

These are described in more detail, along with projected uptake in the baseline in the following section.
Without coordinated deployment and quick uptake, the societal, economic and environmental benefits of C-ITS services will fall below their full potential. This is because the positive network effects associated with faster deployment of interoperable C-ITS stations and services will not be achieved. Redundancies and a reduced network effect will lead to higher costs for involved stakeholders. Lower levels of deployment mean that the corresponding benefits associated with vehicle, infrastructure, and personal C-ITS device equipment investments will be lower.

Countries around the world (e.g. US, Australia, Japan, Korea and China) are moving rapidly towards deploying digital technologies, and in some countries vehicles and C-ITS services are already available on the market. Delays to C-ITS deployment would put the European industry at a disadvantage compared to its competitors, leading to lower levels of new business opportunities in the area along with lower levels of job creation, and less significant research and innovation impacts on the overall European economy. As the jobs of 13.3 million Europeans (6 percent of the EU working population) depend directly or indirectly on the automotive and wider transport industries, it is thus critical that the sector is provided with the conditions to keep up with global market players.13

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3. **DEFINITION OF BASELINE**

3.1. **Overview of the baseline**

The baseline scenario is defined first and represents the option with no further action taken, beyond existing EU policy and legislation. It considers:

- Existing activities (e.g. regional and national deployment projects, such as those coordinated through the C-Roads Platform): these projects are likely to lead to significant regional deployments, although with poor coverage of services, low levels of interoperability and no widespread adoption.

- Industry announcements on deployment targets\(^ {14}\).

Under Article 6(3) and Annex I of the ITS Directive, the Commission has a legal obligation to adopt specifications on cooperative systems. As a result, the baseline is not a valid policy option but is used for comparison purposes only.

Annex F has a comprehensive list and description of the 87 deployment projects tracked. It also gives the years of activity for the projects and their status. These expected developments have been used in the background to help define the baseline and feed into the baseline C-ITS technology penetration assumptions. These do not feed directly into the uptake assumptions used to quantify the modelled baseline, however they have been used as a guide to overall expected uptake over time.

Instead, the starting point in terms of C-ITS technology penetration assumptions was the baseline that we developed as part of the 2016 C-ITS Deployment study for DG MOVE (Ricardo-AEA, 2016), which began with a similar desk research exercise (now updated as part of this study) and then formulated uptake assumptions which were later tested and refined with expert groups. Further, the ASTRA model has been calibrated to an update of the EU Reference scenario 2016\(^ {15}\) and the impacts of C-ITS on safety have been calibrated to take into account the potential overlap of impacts in the General Safety Regulation (GSR) Regulation for vehicles, adopted by the Commission in May 2018.

Information on deployment projects, however, has been used to define country groupings using the percent of road network equipped with C-ITS and the assumption for the 50/50 weighting between short-range and long-range communications technologies. See section 3.3.3 for further details.

Table 3-2 gives a general overview of all the types of measures considered in the baseline, which are also then considered in each policy option. The list of measures selected address all eight of the root causes identified in the problem definition (see Figure 2-1). While most of the root causes translate one to one into policy measure groups, the root causes relating to coordination and communication measures (Root

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\(^ {15}\) This scenario includes some updates in the technology costs assumptions (i.e. for light duty vehicles) and few policy measures adopted after its cut-off date (end of 2014) like the Directive on Weights and Dimensions, the 4th Railways Package, the NAIADIES II Package, the Ports Package, the replacement of the New European Driving Cycle (NEDC) test cycle by the new Worldwide harmonized Light-vehicles Test Procedure (WLTP), the impact of newly adopted vehicle technologies safety measures and voluntary uptake of vehicle technology safety measures. It has been developed with the PRIMES-TREMOVE model (i.e. the same model used for the EU Reference scenario 2016) by ICCS-E3MLab. A description of this scenario is available in the Impact Assessment accompanying the Proposal for a Directive amending Directive 2008/96/EC on road infrastructure safety management, SWD (2018) 175 final.
causes 4 and 6) are not covered by individual sets of measures, but instead fall under the themes of security/compliance assessment and interoperability, respectively, to avoid overlap/repetition.

**Table 3-1: Description of types of measures and the root cause(s) addressed**

<table>
<thead>
<tr>
<th>Root cause</th>
<th>Policy measure group</th>
<th>Description of measures and the root cause(s) addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Enabling conditions</td>
<td>Cross-cutting enabling measures, addressing root cause #1 “Uncertainty about development towards CCAM / attractive business models”</td>
</tr>
<tr>
<td>#2</td>
<td>Security</td>
<td>Measures to improve security, addressing root cause #2 “Failure to establish the necessary trust regarding cyber security of C-ITS communications”</td>
</tr>
<tr>
<td>#3</td>
<td>Privacy and protection of personal data</td>
<td>Measures to address privacy and protection of personal data, addressing root cause #3 “Uncertainty on how to comply with rules on privacy and protection of personal data”</td>
</tr>
<tr>
<td>#4</td>
<td>Multiple</td>
<td>Cross-cutting coordination measures, addressing root cause #4 “Lack of coordination between relevant bodies”</td>
</tr>
<tr>
<td>#5</td>
<td>Interoperability</td>
<td>Measures to improve interoperability, addressing root cause #5 “Lack of common definition/priority of C-ITS services”</td>
</tr>
<tr>
<td>#6</td>
<td>Multiple</td>
<td>Communication measures to improve interoperability, addressing root cause #6 “Incompatible communication technologies and frequency spectrum allocation” listed separately in the problem tree.</td>
</tr>
<tr>
<td>#7</td>
<td>Continuity</td>
<td>Measures to ensure continuity, addressing root cause #7 “Uncertainties about minimum requirements for interoperability of C-ITS services”</td>
</tr>
<tr>
<td>#8</td>
<td>Compliance assessment</td>
<td>Compliance related measures, addressing root cause #8 “Uncertainties about minimum requirements for compliance assessment for C-ITS services”</td>
</tr>
</tbody>
</table>

**3.2. Defining the baseline for each key theme**

Table 3-2 below shows, under each measure described in the preceding section, how we define the baseline for this study. Some of the initiatives, like the ITS Directive, address cross-cutting issues.
### Table 3-2: Overview of measures considered in the baseline

<table>
<thead>
<tr>
<th>Privacy and protection of personal data</th>
<th>Security</th>
<th>Interoperability</th>
<th>Compliance assessment</th>
<th>Continuity</th>
<th>Enabling conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>o EU policy: ITS Directive, C-ITS Strategy, Connected and automated mobility Strategy</td>
<td>Available non-binding guidance from the C-ITS platform; in particular the common security &amp; certificate policy</td>
<td>List of Day 1 and 1.5 services agreed in the C-ITS platform &amp; 2016 EC Strategy</td>
<td>ETSI Conformance test specifications</td>
<td>Ongoing harmonisation &amp; deployment through C-Roads, CAR2CAR and ITS Committee</td>
<td>Existing MoU C-Roads and C2C-CC Work of Amsterdam Group / CODECS / HL Dialogue Horizon2020 / 5GAA / EATA work</td>
</tr>
<tr>
<td>o Regional and national deployment projects e.g. C-Roads</td>
<td>Available non-binding guidance from C-ITS platform as to the roles/bodies needed (governance framework)</td>
<td>Available non-binding guidance from C-ITS platform as to the roles/bodies needed (governance framework)</td>
<td>Existing standards developed by e.g. ETSI/CEN Voluntary common service profiles available / being developed (e.g. the Car2Car and C-ROADS profiles)</td>
<td>Existing MoU C-Roads and C2C-CC Work of Amsterdam Group / CODECS / HL Dialogue Horizon2020 / 5GAA / EATA work</td>
<td></td>
</tr>
<tr>
<td>o EU funding in the area e.g. under CEF (including funding / set-up of common EU security elements in 2018-2021)</td>
<td>EU C-ITS Security Credential Management System - Pilot 2018 - 2021 (CEF PSA)</td>
<td>EU C-ITS Security Credential Management System - Pilot 2018 - 2021 (CEF PSA)</td>
<td>ETSI Conformance test specifications</td>
<td>Existing compliance assessment processes (e.g. for harmonized standards / CE marking)</td>
<td>Station manufacturers voluntary apply ETSI conformance test specifications</td>
</tr>
<tr>
<td>o Industry deployment of C-ITS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Station manufacturers voluntary apply ETSI conformance test specifications</td>
</tr>
<tr>
<td>General Data Protection Regulation (GDPR) (includes all the requirements, such as mandatory Data protection impact assessment by data controller)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Station manufacturers voluntary apply ETSI conformance test specifications</td>
</tr>
<tr>
<td>ePrivacy Directive and its proposed update</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Station manufacturers voluntary apply ETSI conformance test specifications</td>
</tr>
</tbody>
</table>

Available non-binding guidance from the C-ITS platform; in particular the common security & certificate policy. Available non-binding guidance from C-ITS platform as to the roles/bodies needed (governance framework). EU C-ITS Security Credential Management System - Pilot 2018 - 2021 (CEF PSA).
3.3. Uptake assumptions and projected uptake in the baseline

Following on from the baseline measures presented in Section 3.1, we have made assumptions that are needed to translate the measures into uptake in the baseline. These are organised to present uptake for (i) in-vehicle C-ITS stations (using hybrid communication, i.e. equipped with a combination of short and long-range communication technologies) in new vehicles, (ii) personal C-ITS devices in existing vehicles that are not equipped with in-vehicle C-ITS stations, and (iii) infrastructure uptake.

The deployment rates under the baseline have been established through an iterative process that began by considering the baseline used in the 2016 C-ITS deployment study (Ricardo, 2016), which was the result of significant expert input from the C-ITS Platform Working Group. These rates were further developed based on available literature and expert judgement and finally verification at the stakeholder workshop held in Brussels in February 2018.

The time needed for C-ITS uptake into new vehicles has been reflected by the number of vehicle full-model and facelift cycles, as it is through these updates that C-ITS technology will enter the vehicle fleet. Full model cycles involve vehicle redesigns. Personal transport vehicles are assumed to have full model cycles of 7 years\textsuperscript{16} while public service vehicles (buses) and freight vehicles are assumed to have longer cycles of 9 years. These model lifecycles were presented and validated at the stakeholder workshop. Facelift cycles occur between full-model redesigns and comprise minor upgrades to vehicle functionality and styling that occur midway through a model’s lifecycle to keep market interest in the vehicle high. Personal transport vehicles are assumed to have facelift cycles of 4 years and public & freight transport are assumed to have longer facelift cycles of 5 years.

3.3.1. Uptake assumptions and uptake for C-ITS subsystems in new vehicles

In new vehicles, baseline uptake is based on the uptake of C-ITS service bundles 1, 2, and 3, which are all Day 1 services. Further descriptions of the bundles considered in this study can be found in Annex B. Table 3-3 presents the uptake assumptions for C-ITS services in new vehicles.

\textsuperscript{16} Assumed value substantiated by analysis of the generation model cycles of 16 personal vehicles (4 from each car category: A/B,C,D,E/F). Values of 7 years for cars and 9 years for freight were agreed as reasonable by stakeholders at the workshop.
Table 3-3: Baseline - uptake assumptions for ITS services in new vehicles

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Bundle 1</th>
<th>Bundle 2</th>
<th>Bundle 3</th>
<th>Bundles 4, 5, 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Transport</td>
<td>Uptake across all car categories reaches 100% in 5 vehicle full model cycles (5x7 years = 35 years) starting in 2019.17</td>
<td>No Uptake</td>
<td>Uptake also reaches 100% in 5 full model cycles starting 2019, but over 45 years (5x9 years) to reflect different model cycles.</td>
<td>No Uptake</td>
</tr>
<tr>
<td>Public Transport</td>
<td>No Uptake18</td>
<td>No Uptake</td>
<td>No Uptake</td>
<td>No Uptake</td>
</tr>
<tr>
<td>Freight</td>
<td>Uptake also reaches 100% in 5 full model cycles starting 2019, but over 45 years (5x9 years) to reflect different model cycles.</td>
<td>No Uptake</td>
<td>No Uptake</td>
<td>No Uptake</td>
</tr>
</tbody>
</table>

Key assumptions and inputs

- The baseline for C-ITS deployment was developed together with stakeholders at the workshop in February 2018. It builds on the baseline used in the 2016 C-ITS deployment study (Ricardo, 2016) which was developed together with technical experts in working groups under the C-ITS platform.

- The uptake start year (2019) is based on the Memorandum of Understanding between the CAR 2 CAR Communication Consortium and the C-Roads Platform, which aims for initial C-ITS deployment across Europe by 201919 (CAR 2 CAR Communication Consortium & C-Roads Platform, 2017).

- Personal transport vehicles assumed to have full model cycles of 7 years20 and public and freight transport assumed to have longer full model cycles of 9 years21. These model lifecycles were presented and validated at the stakeholder workshop.

- Bundles 4, 5 and 7 (Day 1.5 services) are not deployed in the baseline as observed in current C-ITS deployment projects. They are also not deployed in the three policy options modelled but are included in the deployment scenarios (see Annex C).

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17 This assumption is consistent with work for the RISM/GSPR baseline assuming Medium uptake with 40% voluntary propagation within the fleet without additional stimuli over the course of 14 years.

18 Public transport vehicles have no uptake for bundles 1 and 2 in the baseline. This is an assumption developed from expert consultations as part of the 2016 Deployment Study.

19 2019 is also in line with the start year referenced in the European Commission’s C-ITS Strategy.

20 “Vehicle model cycle” is the length of time that a particular vehicle model is on sale for before being replaced in the market by the next generation of that model. Assumed model cycle length of 7 years substantiated by analysis of the model cycles of 16 passenger car models (4 from each category).

21 Stakeholders validated this assumption in the workshop held on 9th February 2018. This assumption is the same as that used in the 2016 C-ITS Deployment Study (Ricardo, 2016).
It is assumed that uptake rates in new vehicles are the same across all countries, although penetration into the fleet differs by Member State due to different rates of fleet renewal.

Figure 3-1 presents the uptake of C-ITS sub-systems in different vehicles.

**Figure 3-1: Uptake of C-ITS sub-systems in new vehicles in the baseline**

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**3.3.2. Uptake assumptions and uptake for personal C-ITS devices**

For existing vehicles in the fleet, it is assumed that C-ITS services will only be accessed by retrofit through smartphones, which are equipped to deliver C-ITS services via a downloadable application. European sales of personal navigation devices (PND) have reduced from 17 million to 5 million between 2008 and 2016 (Statista, 2017), and smartphone C-ITS applications are already being developed (e.g. C-Mobile and NordicWay). Uptake rates for these personal C-ITS stations are assumed to be closely linked with the uptake in new vehicles. Table 3-4 presents the uptake assumptions considered in the baseline.
Table 3-4: Baseline - uptake assumptions for personal C-ITS stations in existing vehicles

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Bundle 1</th>
<th>Bundle 2</th>
<th>Bundle 3</th>
<th>Bundle 4, 5 and 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Transport</td>
<td>No Uptake</td>
<td></td>
<td>Uptake of personal C-ITS devices will start at the same time as in new vehicles. It progresses linearly, in line with uptake in new vehicles, following trajectory whereby maximum uptake (95%) in personal C-ITS devices would be reached when penetration in new vehicles reaches 100%.</td>
<td>No Uptake</td>
</tr>
<tr>
<td>Public Transport</td>
<td></td>
<td>No Uptake</td>
<td>Same assumption as for personal transport, but following uptake in new public transport vehicles, rather than passenger cars</td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>No Uptake</td>
<td></td>
<td>Same assumption as for personal transport, but following uptake in new freight vehicles, rather than passenger cars</td>
<td></td>
</tr>
</tbody>
</table>

Key assumptions and inputs:

- Personal C-ITS devices are assumed to involve smartphones only and operate using a cellular network connection.
- Due to the population age distribution, there will always be a percentage that will not have a smartphone\(^2\) and so maximum uptake is limited to 95 percent.
- It is assumed that penetration for personal C-ITS devices is linked to the start year and maximum value of penetration in new vehicles. Feedback from an expert group meeting highlighted that C-ITS can already be provided by mobile phones and so it is reasonable to assume that uptake will at least begin in line with new vehicle C-ITS sub system uptake. This is seen as a neutral assumption in the absence of data to support an assumption that deployment in smartphones will increase more rapidly or more slowly than uptake in new vehicles.
- It is assumed that personal C-ITS devices are unable to deliver the safety V2V services of Bundle 1, because this would require access to vehicle information and low-latency communication currently not feasible in smartphones, although we acknowledge it may be possible in the future.
- Similar uptake rates are used for freight and passenger cars, although it is expected that the devices themselves and the business models for their inclusion will be different.
- It is assumed that percentage uptake rates of personal C-ITS systems in the fleet not equipped with in-vehicle C-ITS stations are the same across all countries (i.e. independent of fleet renewal).

Figure 3-2 below shows how uptake in personal C-ITS devices is related to uptake in new vehicles.

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\(^2\) Based on previous Ricardo work on C-ITS.
3.3.3. Uptake assumptions and uptake for infrastructure

In this study, we divide EU countries into three country groupings (Front Runners, Planned Adopters, and Followers) according to the number of C-ITS projects in countries and the length of road network where the technology has been deployed. This is particularly important for infrastructure assumptions and uptake. Countries in the top ten ranking for the number of projects and the share of the network equipped are defined as Front Runner Countries. Follower countries have no network equipped at present and Planned Adopters comprise the remaining countries. Further details on country groupings are in Annex B. Assumptions are also defined separately for infrastructure type (RSU or cellular) and for the five principal road types (TEN-T Corridor, Core TEN-T, Other Motorways, Other Interurban Roads and Urban Roads). Table 3-5 provides an overview of the infrastructure uptake assumptions for the baseline.
Table 3-5: Baseline - uptake assumptions for infrastructure in all country groupings

<table>
<thead>
<tr>
<th>Road type</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEN-T Corridor</td>
<td>Roadside unit (RSU): Use actual data on average deployment levels expected to be achieved by 2020 in each country grouping, assumed constant thereafter. Cap uptake in the year C-Roads runs out (2020).&lt;sup&gt;23&lt;/sup&gt; Cellular: assume an 84% coverage&lt;sup&gt;24&lt;/sup&gt;</td>
</tr>
<tr>
<td>TEN-T Core (remainder of TEN-T network)</td>
<td>RSU: No uptake Cellular: assume an 84% coverage</td>
</tr>
<tr>
<td>Other Motorways (TEN-T Comprehensive)</td>
<td>RSU: No uptake Cellular: assume an 84% coverage</td>
</tr>
<tr>
<td>Other Interurban Roads</td>
<td>RSU: No uptake Cellular: assume an 84% coverage</td>
</tr>
<tr>
<td>Urban</td>
<td>RSU/Cellular: Front Runners 8% (traffic light stock that is replaced each year) x 25% (new traffic lights equipped) per year from 2020 Planned Adopters/Followers: uptake scaled based on TEN-T Core/Corridor uptake rates in Front Runners, and delayed by 2 and 4 years for each group respectively.</td>
</tr>
</tbody>
</table>

Key assumptions and inputs:

- Data from deployment projects within each country grouping (Front Runner, Planned Adopter, Follower) has been used to assess the percent of road network equipped with RSUs to 2020.

- In the baseline, it is assumed that from 2020 (when the current C-Roads projects are finished) there will be no further installation of roadside units and the 2020 level is maintained until 2035. For Follower countries, that have no roll-out of C-ITS infrastructure to date this means that the baseline assumes no uptake in RSU infrastructure. While this is a conservative assumption, the high cost barriers for RSU roll-out due to persisting interoperability issues and the resulting uncertainty around business models in the baseline, will most likely mean that without additional EU funding being made available, these countries will not deploy on their own. While no RSU roll-out is assumed there will be still cellular infrastructure and in-vehicle deployment.

- Deployment of central C-ITS sub-systems: It is assumed that once penetration along TEN-T corridors reaches 5 percent, a central C-ITS sub-system is required and when urban penetration reaches 10 percent another C-ITS sub-system is required<sup>25</sup>.

- The cellular coverage represents geographical coverage across the EU of 84 percent. For urban areas, we assume dedicated infrastructure will be required. In our modelling, we have used traffic light replacement as a proxy for this infrastructure rollout. In urban areas, it is assumed that 25 percent of new traffic

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<sup>23</sup> The baseline assumes no further installation of C-ITS infrastructure beyond that resulting from existing or planned projects to 2020 (based on the year C-Roads projects conclude).

<sup>24</sup> This is based on current average 4G/LTE geographic coverage for Europe (European Commission, 2016). In practice, we believe actual cellular coverage on transport routes is currently lower, but as we expect it to increase over time, we have used the current geographic coverage.

<sup>25</sup> These figures were based on the consultation with experts during the 2016 Deployment Study.
lights are equipped with transmitters beyond 2020. Deployment is calculated assuming a 12.5-year traffic light lifetime, which is based on consultation with stakeholders as part of the 2016 C-ITS Deployment study (Ricardo, 2016).

- An assessment of existing deployment projects in Front Runner countries has revealed an approximately 50:50 split between countries planning to deploy RSUs vs. using the cellular networks. A count was made on the numbers of deployment projects in each Member State that were associated with short range, cellular or both technologies. The Member State count was aggregated for each country grouping and we then calculated a ratio between the two technologies. As such, the weighted average infrastructure penetration for future years is based on this 50:50 split. We apply the same split for all country groupings as we expect other countries to follow the example of Front Runners in deployment. It is important to note that this represents the current observed situation which might change in the future based on functional and financial considerations.

Figure 3-3 and Figure 3-4 present the uptake of RSU infrastructure in the baseline for each country grouping in TEN-T Corridor/Core and urban roads, respectively. Uptake on other motorways and other interurban roads is assumed to be zero and uptake on all roads in Follower countries is zero in the baseline, based on average deployment levels to date in each country.

**Figure 3-3: Uptake of RSU infrastructure in the baseline in Front Runner (FR), Planned Adopters (PA), and Followers (F) in TEN-T Corridor/Core roads**

![Uptake of RSU infrastructure in the baseline in Front Runner (FR), Planned Adopters (PA), and Followers (F) in TEN-T Corridor/Core roads](image-url)
3.4. Modelled baseline

This section describes the modelled baseline to explain the main implications of the C-ITS uptake assumptions. Detailed and comprehensive comparisons of the baseline with each policy option will be presented in Section 5. Note that this baseline, assessed with the ASTRA/TRUST models, builds on the updated 2016 EU Reference scenario used in the impact assessments accompanying the RISM/GSPR initiatives but includes additional policy measures and initiatives related to C-ITS. The baseline scenario therefore assumes the application of the existing General Safety Regulation and Road Infrastructure Safety Management Directive in line with the current legislation, as required by the Better Regulation principles. There is little to no overlap between the technologies considered in RISM/GSPR baseline and the additional C-ITS measures considered in this study aside from intelligent speed assistance, which could be equated with the in-vehicle speed limits (VSPD) service we model as part of Bundle 2.

While there is little to no overlap between the baseline for this study and the RIMS/GSR baseline for the technologies, there are some overlapping impacts. This is due to the overlapping effects between the impacts of the policies, in the same way as there is nearly always more than one factor in accident causation. The individual influence of each factor is virtually impossible to determine. In other words, the combined effect of road infrastructure, vehicle safety and C-ITS measures deployed together, is going to be somewhat lower than the sum of their individual effects. Under GSR predicted impacts, accidents (the only impact modelled) reduce by 7-8 percent in the policy options. For this reason, we have reduced the benefit of C-ITS services on safety by 10 percent across all C-ITS services in our study in the baseline and policy options modelled. This reduction will more than account for any overlaps between the effect of C-ITS services on safety and those of the RISM/GSR Regulations26.

26 Other impacts are not reduced in the same way, as these are not quantified in the support study produced for the GSR Regulation.
A key impact is safety. While there has been a positive trend in road safety in the EU over the last decades, this trend has recently slowed down. Figure 3-5 below shows our projected baseline trend in accidents by type of accident, in index form.

**Figure 3-5: Baseline number of accidents by type relative for the EU28 (2015=100)**

Overall, in 2030, the annual number of total accidents is expected to be 1.35 million in the baseline. In 2035, this number decreases to 1.30 million.

**Table 3-6: Baseline annual number of accidents for the EU28 – 2015, 2030 and 2035**

<table>
<thead>
<tr>
<th>Accident Type</th>
<th>Annual Accidents</th>
<th>2015</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatalities</td>
<td></td>
<td>26,100</td>
<td>22,900</td>
<td>21,400</td>
</tr>
<tr>
<td>Serious injuries</td>
<td></td>
<td>249,000</td>
<td>229,000</td>
<td>221,000</td>
</tr>
<tr>
<td>Minor injuries</td>
<td></td>
<td>1,185,000</td>
<td>1,096,000</td>
<td>1,052,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1,460,000</strong></td>
<td><strong>1,348,000</strong></td>
<td><strong>1,294,000</strong></td>
</tr>
</tbody>
</table>

Note: Fatalities have been rounded to the nearest 100 and other accident figures have been rounded to the nearest 1,000.

The baseline impacts of accidents, as quantified in our study means that in 2030 and 2035, the annual costs (in constant 2017 prices) of total accidents will reach €134.6 billion and €128.7 billion, respectively. These are shown along with the breakdown by accident type in Table 3-7.

**Table 3-7: Baseline annual costs of accidents for the EU28 – 2015, 2030 and 2035**

<table>
<thead>
<tr>
<th>Accident Type</th>
<th>Annual Accident Costs</th>
<th>2015</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatalities</td>
<td></td>
<td>€50.4 bn</td>
<td>€44.4 bn</td>
<td>€41.6 bn</td>
</tr>
<tr>
<td>Serious injuries</td>
<td></td>
<td>€71.4 bn</td>
<td>€66.0 bn</td>
<td>€63.8 bn</td>
</tr>
<tr>
<td>Minor injuries</td>
<td></td>
<td>€26.3 bn</td>
<td>€24.3 bn</td>
<td>€23.4 bn</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>€148.1 bn</strong></td>
<td><strong>€134.6 bn</strong></td>
<td><strong>€128.7 bn</strong></td>
</tr>
</tbody>
</table>
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Taking into account the entire model period, the present value of total accident costs in the baseline between 2020 and 2030 will reach €1,166 billion and between 2020 and 2035 will reach €1,531 billion. While the policy options in this study begin in 2019, they do not yield impacts until 2020 and baseline impacts are presented over the same time period for consistency.

Table 3-8: Baseline cumulative PV of accident costs for the EU28 – 2030 and 2035

<table>
<thead>
<tr>
<th>Accident Type</th>
<th>Cumulative cost of accidents</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PV 2020-2030</td>
<td>PV 2020-2035</td>
<td></td>
</tr>
<tr>
<td>Fatalities</td>
<td>€388 bn</td>
<td>€507 bn</td>
<td></td>
</tr>
<tr>
<td>Serious injuries</td>
<td>€563 bn</td>
<td>€743 bn</td>
<td></td>
</tr>
<tr>
<td>Minor injuries</td>
<td>€215 bn</td>
<td>€281 bn</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>€1,166 bn</td>
<td>€1,531 bn</td>
<td></td>
</tr>
</tbody>
</table>

The economic impacts of greater C-ITS deployment are expected to be significant in terms of reductions in urban travel time. Congested roads are a huge cost to the EU economy and limited C-ITS uptake adds travel time costs relative to our policy scenarios. In our baseline, the expected travel time cost will be €618.5 billion annually in 2030 and €627.2 billion annually in 2035.

Figure 3-6: Baseline annual urban travel time costs for the EU28 (2015=100)

Overall, in 2030, the total annual urban travel time is expected to be 71 billion hours in the baseline. In 2035, this number increases to 72 billion.
Table 3-9: Baseline annual urban travel time for the EU28 – 2015, 2030 and 2035

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>2015</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>52,000</td>
<td>59,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Bus</td>
<td>11,000</td>
<td>12,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Total</td>
<td>63,000</td>
<td>71,000</td>
<td>72,000</td>
</tr>
</tbody>
</table>

Note: Travel time has been rounded to the nearest 1,000.

The baseline impacts of urban travel time, as quantified in our study means that in 2030 and 2035, the annual costs (in constant 2017 prices) of total urban travel time will reach €618 billion and €627 billion, respectively. These are shown along with the breakdown by vehicle type in Table 3-10.

Table 3-10: Baseline annual urban travel time costs for the EU28 – 2015, 2030 and 2035

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>2015</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>€457 bn</td>
<td>€515 bn</td>
<td>€523 bn</td>
</tr>
<tr>
<td>Bus</td>
<td>€92 bn</td>
<td>€103 bn</td>
<td>€104 bn</td>
</tr>
<tr>
<td>Total</td>
<td>€549 bn</td>
<td>€618 bn</td>
<td>€627 bn</td>
</tr>
</tbody>
</table>

Between 2020 and 2030, the present value of the travel time cost in our baseline will reach €5,030 billion. For 2020 to 2035, the present value will be €6,764 billion.

Table 3-11: Baseline cumulative PV urban travel time costs for the EU28 – 2020-2030 and 2020-2035

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>€5,030 bn</td>
<td>€6,764 bn</td>
</tr>
</tbody>
</table>

In terms of environmental impacts, road transport is responsible for the bulk of transport-related emissions of greenhouse gases and air pollutants. Greater deployment of C-ITS could help the EU achieve further environmental benefits beyond the baseline scenario, where a decrease in environmental impacts is already evident through to 2035. Annual CO₂ emissions are projected to decrease in the baseline by 13 percent between 2015 and 2030 (15 percent between 2015-2035) (see Figure 3-7).
Overall, in 2030, the total annual CO\textsubscript{2} emissions is expected to be 728 million tonnes in the baseline. In 2035, this number decreases to 709 million tonnes.

**Table 3-12: Baseline annual CO\textsubscript{2} emissions for the EU28 – 2015, 2030 and 2035**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Annual Emissions (thousand tonnes)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO\textsubscript{2}</td>
<td>834,000</td>
<td>728,000</td>
</tr>
</tbody>
</table>

Note: CO\textsubscript{2} emissions have been rounded to the nearest 1,000.

In 2030 and 2035, the annual costs (in constant 2017 prices) of CO\textsubscript{2} emissions will reach €71 billion and €69 billion, respectively. This is shown in Table 3-13 below.

**Table 3-13: Baseline annual CO\textsubscript{2} emission costs for the EU28 – 2015, 2030 and 2035**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Annual Emission costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO\textsubscript{2}</td>
<td>€81.1 bn</td>
<td>€70.8 bn</td>
</tr>
</tbody>
</table>

Figure 3-8 below presents expected annual baseline emissions trends for PM, NO\textsubscript{x} and VOC between 2015 and 2035. The NO\textsubscript{x} emissions are expected to decrease by 53 percent during 2015-2030 (60 percent for 2015-2035) while the PM emissions would go down by 38 percent during 2015-2030 (39 percent for 2015-2035) and VOC would decrease by 25 percent during 2015-2030 (24 percent for 2015-2035).\textsuperscript{28}

\textsuperscript{27} Based on tank-to-wheel CO\textsubscript{2} emissions for cars, buses/coaches, LDVs and HDVs.

\textsuperscript{28} The slight increase in VOC between 2030 and 2035 (despite an overall drop from 2015 to 2035) is related to increased transport demand for car and HGV traffic and the resulting emissions.
While all air pollutant emissions are expected to fall, as displayed in Table 3-14, NOx is the key pollutant.

**Table 3-14: Baseline annual air pollutant emissions for the EU28, by pollutant for 2015, 2030 and 2035 (Tonnes)**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Annual Emissions (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015</td>
</tr>
<tr>
<td>PM</td>
<td>161,000</td>
</tr>
<tr>
<td>NOx</td>
<td>2,117,000</td>
</tr>
<tr>
<td>VOC</td>
<td>118,000</td>
</tr>
</tbody>
</table>

Note: Pollutant emissions have been rounded to the nearest 1,000.

In 2030 and 2035, the annual costs (in constant 2017 prices) of pollutant emissions will reach €17 billion and €15.2 billion, respectively. These are shown along with the breakdown by pollutant type in Table 3-15.

**Table 3-15: Baseline annual air pollutant emissions costs for the EU28, by pollutant for 2015, 2030 and 2035**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Annual Emission costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015</td>
</tr>
<tr>
<td>PM</td>
<td>€7.4 bn</td>
</tr>
<tr>
<td>NOx</td>
<td>€26.1 bn</td>
</tr>
<tr>
<td>VOC</td>
<td>€0.2 bn</td>
</tr>
<tr>
<td>Total</td>
<td>€33.7 bn</td>
</tr>
</tbody>
</table>

Despite the falls in levels of CO₂ emissions, the present value of cumulative CO₂ emissions costs between 2020 and 2030 will reach €630 billion (€823 billion by 2035).
This is shown below in Table 3-16. The present value of other air pollutant external damage costs between 2020 and 2030 will reach €187 billion (€231 billion by 2035). This is shown in Table 3-17, along with the breakdown by air pollutant.

**Table 3-16: Baseline cumulative PV CO₂ emissions costs for the EU28: 2020-2030 and 2020-2035**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>€630 bn</td>
<td>€823 bn</td>
</tr>
</tbody>
</table>

**Table 3-17: Baseline cumulative PV air pollutant external damage costs for the EU28: 2020-2030 and 2020-2035**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM</td>
<td>€45 bn</td>
<td>€58 bn</td>
</tr>
<tr>
<td>NOx</td>
<td>€140 bn</td>
<td>€171 bn</td>
</tr>
<tr>
<td>VOC</td>
<td>€1 bn</td>
<td>€2 bn</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>€187 bn</strong></td>
<td><strong>€231 bn</strong></td>
</tr>
</tbody>
</table>
4. **Policy measures and options**

4.1. **Policy objectives**

The general objective is to establish a clear legal framework to increase deployment and uptake of C-ITS services across the EU, with the aim to significantly improve road safety and traffic efficiency.

The specific objectives are threefold:

- to provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models;
- to reduce barriers and uncertainties to enable large-scale deployment of C-ITS; and
- to ensure interoperability and continuity of C-ITS services across the EU.

4.2. **Long list of policy measures**

Based on literature research, stakeholder input and discussions with the Commission services, a long list of policy measures was developed. To help identify and prioritise which measures from the long list should be included in the draft policy options, a scoring system based on a Multi Criteria Analysis (MCA) framework was used. For each of the measures the following was assessed:

- Technical feasibility
- Legal feasibility
- Societal acceptance
- Effectiveness
- Efficiency
- Proportionality
- Relevance
- EU added value

This qualitative assessment was informed through discussions with the Commission services, deliberations between technical experts within the consultants’ team and literature / stakeholder statements where applicable. Based on the findings, measures were scored through a red, amber, green system individually for each of the above aspects. Table 4-1 gives an overview of the assessment of each individual measure considered, using this framework. Based on this assessment, and as described in the ‘Rationale’ column of Table 4-1, a number of measures were discarded, either due to low feasibility or being outside of the scope of the intervention. Some measures were merged with other measures. Each remaining measure was then allocated to a theme linked to the root causes defined in the problem definition.

The findings of the MCA allowed us to narrow down the list of measures in order to proceed with the development of concise policy options.

From the shortened list of policy measures, the project team together with the Commission has developed three policy options, as outlined in Section 4.4 to 4.6.
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
<thead>
<tr>
<th>Qualitative scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>✗ ✗     ✗     ☐     ☑   ☑</td>
</tr>
<tr>
<td>Very low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feasibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

NC
Not considered for final policy options, due to low feasibility, being outside the scope or being incorporated in other measures.
### Table 4-1: Long list of policy options - MCA

<table>
<thead>
<tr>
<th>Theme</th>
<th>Policy Option</th>
<th>Measure</th>
<th>Technical feasibility</th>
<th>Legal feasibility</th>
<th>Societal acceptability</th>
<th>Effectiveness</th>
<th>Efficiency</th>
<th>Proportionality</th>
<th>Relevance</th>
<th>EU added value</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Privacy and protection of personal data</td>
<td>1</td>
<td>EC adopts non-binding application guidelines for the GDPR in the context of C-ITS, including the responsibilities and requirements.</td>
<td>y</td>
<td>Y</td>
<td>✓</td>
<td>×</td>
<td>O</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Many stakeholders stated that more clarity was needed around the GDPR. Guidelines are a low-cost intervention that will have some impact on data privacy as it will remove uncertainty. This will help C-ITS service providers to have more clarity on how personal data can be used in the context of C-ITS. Since data is a valuable commodity, it will help firms develop better business models.</td>
</tr>
<tr>
<td></td>
<td>1, 2</td>
<td>Establishing purposes for lawfully processing personal data as traffic safety &amp; efficiency, with limitations (no commercial or law enforcement use)</td>
<td>y</td>
<td>Y</td>
<td>✓</td>
<td>✓</td>
<td>O</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>In addition to the benefits of the guidelines, this measure will have a stronger impact on deployment as it sets out how exactly personal data can be used in the context of C-ITS. While there are still limitations for the use of data i.e. cannot be used for commercial or law enforcement use, the basic purpose of C-ITS (improve traffic efficiency and road safety) can be achieved and the effectiveness of this measure is expected to be high.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>EC adopts application specifications for the GDPR in the context of C-ITS, including the responsibilities and requirements</td>
<td>y</td>
<td>C</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Concrete requirements/responsibilities around the GDPR will increase uptake. It might encourage businesses to join the market since uncertainties around how the GDPR is applied to C-ITS is removed (although the GDPR should not be interpreted through other legislation). Furthermore, it reduces the risk and cost for businesses to understand how they can be compliant. Given the lack of trust from users regarding the use of personal data (as established in the problem definition) this measure would increase user acceptance (since the rules will be set out clearly) and thus increase demand.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Establishing purposes for lawfully processing personal data as traffic safety &amp; efficiency, with limitations. + Lawfully processing data based on legal obligation or public interest.</td>
<td>y</td>
<td>C</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Introducing limitations in data use will affect the scope of use of data collected through C-ITS. The introduction of a legal instrument through co-decision can introduce a legal ground for the processing of personal data related to C-ITS, which would clarify the reasons and approach to processing C-ITS messages.</td>
</tr>
<tr>
<td>Requirements &amp; procedures</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>EC adopts non-binding guidelines on the European Union C-ITS Security Credential Management System (EU CCMS)</td>
<td>Y</td>
<td>Y</td>
<td>✓ ✓</td>
<td>O</td>
<td>✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Contents of the European Union C-ITS Security Credential Management System (EU CCMS) in EU law specifying C-ITS security requirements &amp; procedures for all C-ITS stations. Possibility to update, e.g. through a review clause.</td>
<td>Y</td>
<td>C</td>
<td>✓ ✓ ✓</td>
<td>✓ ✓ ✓</td>
<td>✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>EC adopts non-binding guidelines on governance structure/bodies needed for security, recommendations to assign roles to bodies, based on governance framework included in security policy</td>
<td>Y</td>
<td>Y</td>
<td>✓ ✓</td>
<td>×</td>
<td>O</td>
<td>✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Definition of needed roles in EU CCMS in EU law + information to the Commission on the bodies/authorities in charge if they have been set up.</td>
<td>y</td>
<td>C</td>
<td>✓ ✓ ✓</td>
<td>✓ ✓ ✓</td>
<td>✓ ✓ ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Stakeholders highlighted the lack of trust around security of C-ITS as one of the key barriers. Guidelines around the EU CCMS are a low cost intervention that will have some positive impact on security, by introducing a voluntary EU Security Credential Management System. On the user side it will reduce some of the concerns, however only to a limited extent.**

**Putting the contents of the EU CCMS into law will have a significant impact on the effectiveness of the C-ITS system as enrolment in the EU Security Credential Management System is a pre-requisite needed for operation. EU level intervention on security is important, as it is only in this way that interoperable security of the EU C-ITS system as a whole can be ensured. Where C-ITS is deployed, services will follow the same rules which will make the whole system safer and more effective. It is expected to significantly increase user acceptance of C-ITS services and thus will positively impact uptake.**

**Guidance on governance structures and bodies needed to oversee C-ITS security will generally improve coordination and cooperation across the EU. As non-binding guidelines the measure will be low-cost but only of limited effectiveness.**

**The requirement for Member States to report on the bodies/authorities in charge where set up will increase transparency and public knowledge. Knowledge sharing across countries deploying C-ITS will be facilitated.**

**Assigning security roles to legal bodies in Member States will result in the highest impact, with regards to coordination across Europe and compliance with security requirements. Assigning these roles however, will require a co-decision procedure and thus technical/legal feasibility is critical. In addition, the measure imposes an extra mandatory cost.**

**The introduction of such a voluntary measure will have a limited effect but positive impact on interoperability. Interoperability helps the EU access the benefits of C-ITS earlier. The more vehicles that are interoperable the sooner network effects can be achieved.**

**With binding specifications, interoperability (where C-ITS is voluntarily deployed) will be significantly impacted. Clarity around the definition of Day 1 services will make**
## Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Impact on System Uptake</th>
<th>Future Proofing</th>
<th>Interoperability</th>
<th>Business Case</th>
<th>Deployment Impact</th>
<th>Interoperability Effects</th>
<th>Business Model Clarity</th>
<th>Technological Change Feasibility</th>
<th>Business Case Clarity</th>
<th>Interoperability Effects</th>
<th>Business Model Clarity</th>
<th>Technological Change Feasibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-ITS stations to be compatible with all Day 1 services</td>
<td>the system more attractive to businesses and users and can thus result in increased uptake.</td>
<td>A requirement for all C-ITS stations to be compatible with all Day 1 services makes the stations/hardware more future proof. This is important for a robust C-ITS business case, since it ensures the investment in equipment will have a long lifespan.</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Reference to existing standards on interoperability and EU-wide service profiles (such as those prepared by CAR2CAR and C-ROADS) in guidelines</td>
<td>This voluntary measure will have a limited effect but positive impact on interoperability. Reference to existing EU-wide service profiles will provide more clarity for all C-ITS stakeholders and lead to more coordinated deployment.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mandate to EU level standardisation organisations for standardization of services beyond the Day 1 list.</td>
<td>This measure is future looking and will help accelerate uptake of day 1.5 (and higher) services. It will speed up development of C-ITS on the industry side. Impact on deployment is expected in the long term. Given that a lot of services beyond Day 1 (e.g. smart routing) have direct positive impacts on users (e.g. reduction of travel time) demand for C-ITS will increase.</td>
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<td></td>
</tr>
<tr>
<td>Mandate compliance with existing standards on interoperability in specifications, Possibility to update, e.g. through a review clause</td>
<td>A mandate of existing standards on interoperability will ensure that C-ITS services, where deployed, will be interoperable. This will ensure that benefits can be accessed more easily which will result in stronger incentives for deployment. More certainty around the specifications for interoperability will ensure that C-ITS service providers will have a clearer view of the requirements that need to be met which will improve the clarity around suitable business models. In increasing interoperability, greater network effects are achieved earlier. Feasibility is critical because updating specifications to keep pace with technological changes may be challenging.</td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mandate compliance with EU-wide service profiles of Day 1 services in specifications, Possibility to update, e.g. through a review clause</td>
<td>Similar to the guidance on service profiles for Day 1 services, this measure will have a positive and comparatively stronger impact on interoperability. The legal feasibility is critical since these specifications are still being developed and not put in law yet.</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Human-machine interface functionalities for safety time-critical situations should be harmonised: pictogram formats, colours or positions, auditory warning sounds, haptic warnings.</td>
<td>Very relevant for the functioning of C-ITS, but not within the scope of interoperability of V2V-V2I communication (thus context, rather than measure in this initiative).</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compliance assessment</td>
<td>1</td>
<td>EC adopts non binding guidelines on the compliance assessment process for Day 1 C-ITS services</td>
<td>y</td>
<td>Y</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>O</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Non-binding guidelines will have limited but positive impact on the effective deployment of C-ITS systems.</td>
</tr>
<tr>
<td>-----------------------</td>
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<td>---------------------------------------------------------------------------------------------------</td>
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<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Requirements &amp; procedures</td>
<td>2</td>
<td>Definition of compliance assessment criteria for Day 1 C-ITS services in specifications</td>
<td>y</td>
<td>Y</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>This measure will have a major impact on effectiveness as it ensures that where C-ITS is deployed, services are compliant. Compliance is a prerequisite for all other measures to be effective and is thus indispensable for a functioning C-ITS system.</td>
</tr>
<tr>
<td>Roles/Bodies</td>
<td>2</td>
<td>Approval process for C-ITS stations in specifications</td>
<td>y</td>
<td>Y</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>The provision of an approvals process for C-ITS stations will provide more clarity on how compliance can be assessed and will be mandatory where C-ITS stations are being deployed. This ensures that all C-ITS stations meet the same standards (e.g. in terms of security, interoperability etc.). This in turn will significantly improve the effectiveness of the overall system via greater interoperability.</td>
</tr>
<tr>
<td>1</td>
<td>EC adopts non-binding guidelines to assign roles and responsibilities (e.g. national conformance assessment bodies)</td>
<td>y</td>
<td>Y</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>O</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Guidance on roles and responsibilities for bodies in charge of compliance assessments will generally improve coordination and cooperation across the EU. As non-binding guidelines the measure will be low-cost but only of limited effectiveness.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Define needed roles in relation to the approval process of C-ITS stations + information to the Commission on the bodies/authorities in charge if they have been set up.</td>
<td>y</td>
<td>Y</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>The requirement for Member States to report on the bodies/authorities in charge where set up will increase transparency and public knowledge. Knowledge sharing across countries will be facilitated for those deploying C-ITS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Define needed roles in relation to the approval process of C-ITS stations + Assignment of roles to legal bodies</td>
<td>c</td>
<td>c</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Assigning roles for compliance assessment to legal bodies in Member States will result in the highest impact, with regards to coordination across Europe and compliance with C-ITS requirements. Assigning these roles however, will require a co-decision procedure and thus technical/legal feasibility is critical.</td>
<td></td>
</tr>
<tr>
<td>(nc)</td>
<td>Requirement for any new C-ITS station to fulfil the compliance assessment criteria to be part of the C-ITS security trust model</td>
<td>y</td>
<td>Y</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>No need for separate measure. Incorporated in Compliance Assessment measures above.</td>
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<tr>
<td>(nc)</td>
<td>Mandate mature communication technologies (with exception for pilot technologies, cf. EETS Directive)</td>
<td>c</td>
<td>Y</td>
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<td>✓</td>
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<td>x</td>
<td>x</td>
<td>Removed as more technology neutral measures have been identified.</td>
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### Support study for Impact Assessment of Cooperative Intelligent Transport Systems

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<tbody>
<tr>
<td></td>
<td>Coordination &amp; Policy Advice with stakeholders through stakeholder platform</td>
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<td>Reference principles of Annex II of the ITS Directive (e.g. interoperability, backward compatibility) in guidelines</td>
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<td>Enhanced deployment coordination</td>
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<td></td>
<td>Requirement for repository of digital Traffic Management Plans and Traffic Circulation Plans, to be available via National Access Points</td>
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<td></td>
<td>Develop building blocks for digital Traffic Management Plans and Traffic Circulation Plans and the deployment of Cooperative Incident Management</td>
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<td></td>
<td>Mandatory deployment of V2V communication</td>
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<td></td>
<td>Funding for development of services beyond the Day 1 list</td>
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<td>Enabling conditions</td>
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<td>Y</td>
<td>✓✓</td>
<td>✓✓</td>
<td>✓✓</td>
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</table>

**Continuity**

Success of the C-ITS platform has shown how effective a platform bringing together all types of stakeholders can be. Member State experts have voiced that they would want this. Setting up something similar going forward is expected to be a measure supported by all types of stakeholders.

No need for a separate measure, principles should be integrated in other elements.

Increased coordination for C-ITS deployment will ensure that lessons learnt will be shared across projects. This will help follower countries access lessons learned from front runner countries and accelerate their uptake. Coordination of deployment will also help ensure that the most effective services are deployed in a similar manner. This will help ensure interoperability and continuity of services across borders.

The topic of traffic management is not directly covered by day-1 C-ITS services, and will be covered under the stakeholder platform. Separate measures on this topic is discarded.

Mandatory deployment of V2V communication is the strongest possible measure for V2V uptake and will significantly increase overall C-ITS deployment. High levels of uptake of V2V services are also expected to trigger enhanced V2I deployment. Technical and legal feasibility are critical, as this measure might be outside of the scope of the currently planned intervention and will require more detailed assessment and political consideration. Acceptability might be low at the industry side.

This measure is future-looking and will help accelerate uptake of day 1.5 (and higher) services. It will speed up deployment of C-ITS on the industry side. Impact on deployment is expected in the long term. Given that a lot of services beyond Day 1 (e.g. smart routing) have direct positive impacts on users (e.g. reduction of travel time) demand for C-ITS will increase.
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
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<tr>
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<th>Support Study for Impact Assessment of Cooperative Intelligent Transport Systems</th>
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<tbody>
<tr>
<td>2</td>
<td>Stimulate Day 1 deployment funding by identifying priority funding areas.</td>
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<tr>
<td></td>
<td>By establishing a clear link between deployment funding and common specifications, interoperability and continuity can be achieved in a more effective manner.</td>
</tr>
<tr>
<td>1</td>
<td>MoUs between key stakeholders</td>
</tr>
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<td></td>
<td>MoU can be an effective way of bringing stakeholder together. While the non-binding nature of the measure will limit the impact, it is still expected to have some positive impact on coordination across stakeholder / Member States.</td>
</tr>
<tr>
<td>2</td>
<td>Strengthen funding of deployment to enable quicker uptake, including requirement on data reporting and exchange for deployment projects</td>
</tr>
<tr>
<td></td>
<td>Strengthening the funding for C-ITS deployment will enable quicker uptake (the level will depend on the specific change in the magnitude and nature of the funding). The data reporting and sharing requirements are expected to significantly improve knowledge sharing and help follower countries access learning from front runner countries, thus accelerating their uptake.</td>
</tr>
<tr>
<td>2</td>
<td>Fund EU deployment coordination after current piloting phase</td>
</tr>
<tr>
<td></td>
<td>The provision of funding for EU-level deployment coordination beyond the current piloting phase ensures that coordination at the commercial deployment stage which is important for continuity of services across Europe.</td>
</tr>
</tbody>
</table>
4.3. **Design principle behind policy options**

From the long list of policy measures, three policy options have been developed in an iterative process through discussions between the consultants and the Commission, expert group meetings with Member States and stakeholder consultation.

The three policy options have been defined in a way to reflect an increasing level of regulatory intervention and a corresponding increasing level of expected impacts. Some policy measures, notably those in Policy Option 1, involve non-regulatory instruments (non-binding measures). These policy options are built up from the individual policy measures that were retained in the multi-criteria analysis (described in the preceding section). For each theme (privacy and protection of personal data; security; interoperability; compliance assessment; continuity; and enabling conditions), a set of policy measures were chosen to reflect increasing strength of impact from Policy Option 1 through to Policy Option 3. These themes link back to the root causes of the problem tree, as outlined in Table 3-1.

- **‘Privacy and protection of personal data’** measures respond to the challenge of deploying C-ITS in the context of existing legislation;
- **‘Security’** measures ensure the protection of personal data and the authentication of C-ITS messages, enabling provision of the service;
- **‘Interoperability’** measures enable EU-wide interoperability of C-ITS services, increasing the size of the market, the scope for network effects, and the reliable functioning of the services;
- **‘Compliance assessment’** measures incorporate procedures to ensure adherence to recommended or required specifications for C-ITS services and stations;
- **‘Continuity’** measures pave the way for continuous C-ITS services across borders; and
- **‘Enabling conditions’** measures encourage the market for C-ITS services to flourish.

Policy Option 1 (PO1) consists of a series of non-binding measures such as guidelines, memoranda of understanding (MOUs), stakeholder coordination or knowledge exchange platforms. A similar type of support was provided via the EC’s C-ITS Platform.

Policy Option 2 (PO2) consists of a Delegated Act under the existing ITS Directive. It is a legally binding Act that provides common system and service profiles and definitions of services. For those deploying C-ITS, compliance with the Act would be mandatory.

Policy Option 3 (PO3) builds on the Delegated Act from PO2 and adds a Vehicle to Vehicle (V2V) mandate for deployment of C-ITS that begins in 2021. In addition, PO3 includes the assignment of legal bodies for the C-ITS governance framework.

In the following sections, we present all the policy options by key thematic area (as identified in our Problem Definition), with the different policy measures in each area. The tables in each section will describe the nature of measures that would be implemented across each of the policy options as well as their expected impacts beyond the baseline.
4.4. **Policy Option 1**

4.4.1. **Description of measures under Policy Option 1**

PO1 consists of non-binding measures, such as Memoranda of Understanding (MoUs) between C-ITS deployment stakeholders, or knowledge exchange through stakeholder platforms. In addition, this policy option includes guidelines, i.e. recommendations adopted by the Commission and endorsed by the ITS Committee, which are outside of the specifications of any Delegated Act for the other policy options. The individual measures proposed for this option are listed below in Table 4-2. The table also includes additional details on each measure and a qualitative assessment of their potential impacts.

**Table 4-2: Measures considered under Policy Option 1**

<table>
<thead>
<tr>
<th>Privacy and protection of personal data, including access to data and data quality</th>
<th>Security</th>
<th>Interoperability</th>
<th>Compliance assessment</th>
<th>Continuity</th>
<th>Enabling conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy option 1: soft measures</td>
<td>EC adopts non-binding application guidelines for the GDPR in the context of C-ITS, including responsibilities and requirements.</td>
<td>EC adopts non-binding guidelines on governance structure/ bodies needed for security, recommendations to assign roles to bodies.</td>
<td>EC adopts non-binding guidelines on the provision of services as defined in the list of Day 1 services.</td>
<td>EC adopts non-binding guidelines on the compliance assessment process for Day 1 C-ITS services.</td>
<td>Coordination and policy advice with stakeholders through stakeholder platform.</td>
</tr>
</tbody>
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| | EC adopts non-binding guidelines on standardisation of services beyond the Day 1 list. | EC adopts non-binding guidelines on standardisation of services beyond the Day 1 list. | EC adopts non-binding guidelines on standardisation of services beyond the Day 1 list. | EC adopts non-binding guidelines on standardisation of services beyond the Day 1 list. | Funding for development of services beyond the Day 1 list. MoUs with key stakeholders |

MoUs with key stakeholders
<table>
<thead>
<tr>
<th>Measure description</th>
<th>Privacy and protection of personal data, including access to data and data quality</th>
<th>Security</th>
<th>Interoperability</th>
<th>Compliance assessment</th>
<th>Continuity</th>
<th>Enabling conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-binding specifications on how the GDPR has to be applied in the context of C-ITS services are provided to remove uncertainties. Such a measure could cover guidance on the principle of privacy by design and by default.</td>
<td>Requirements &amp; procedures</td>
<td>Roles/Bodies</td>
<td>Services</td>
<td>Communication specifications</td>
<td>Requirements &amp; procedures</td>
</tr>
<tr>
<td></td>
<td>The policy should apply to the provision of all C-ITS services.</td>
<td>This measure ensures that there are common definitions of roles as identified in the EU CCMS. Under PO1 this is not mandatory, only covered in non-binding guidelines.</td>
<td>In this policy option, Day 1 C-ITS services will be defined in guidelines. This will cover a basic definition of the service, covering whether a service is V2V, V2I, etc.</td>
<td>This measure refers to existing standards on interoperability (e.g. Standards are developed by ESOs (e.g. CEN/ETSI), communication profiles by C-ROADS/CAR2CAR) in a guidance document.</td>
<td>The softest form of a compliance check, through definition of the compliance assessment process in guidelines. It will recommend Member States to check compliance only against the specifications but follow-up actions are not specified and this cannot serve to &quot;approve&quot; C-ITS services stations.</td>
<td>This measure ensures that the roles needed for compliance assessment are defined at EU level in non-binding guidelines.</td>
</tr>
</tbody>
</table>
4.4.2. Expected impact of Policy Option 1 on deployment beyond the baseline

To enable the modelling of indirect impacts (such as accidents rates, fuel consumption, pollutant emissions and travel time) the effects of the different policy measures need to be translated into changes in deployment of C-ITS services compared to the baseline. For PO1 (and PO2) deployment of C-ITS is not mandated and impacts of the policy options on deployment are only indirect. To assess the impact of PO1, in this section we describe the mechanisms and the expected magnitude of the impacts for each different measure. These initial assessments are then, together with input from the Commission and stakeholders, translated into uptake assumptions (as described in section 4.7).

The impacts of the measure under PO1 will be two-fold. On the one hand they will improve user acceptance of services which will result in an increase in demand. On the other hand, PO1 provides more clarity for C-ITS providers which will help with the development of suitable business models and harmonisation across Europe, thereby aiding large scale deployment. However, PO1 is limited to soft measures such as non-binding guidelines and as such is only expected to have limited impact on deployment beyond the baseline. While it will provide more clarity in areas where uncertainty limits uptake and user acceptance (e.g. privacy/protection of personal data, security of C-ITS communication) it only has an impact where these voluntary guidelines are applied. The expected impacts on deployment are discussed by theme below.

The aspect of privacy and protection of personal data is an important point to be addressed to increase the trust of end-users in C-ITS services. The latter is crucial for consumer-driven uptake. The current lack of clarity around compliance with privacy and protection of personal data (as highlighted by stakeholders) can be partially addressed through guidance on the GDPR in the context of C-ITS. However there are limitation as to how far guidelines can go into interpreting the GDPR, and they can give no certainty for a common interpretation across the EU. Thus, the additional impact on deployment compared to the baseline is expected to be small.

Similarly, the lack of trust in security of C-ITS communication was identified as a strong barrier for C-ITS deployment. Guidelines on the EU CCMS policy will provide some more clarity to all stakeholders and increase the trust of the end-user. However, the non-binding nature of the guidelines will only result in increased deployment by those using the systems, and not all will apply it the same way across the EU.

Interoperability is key for C-ITS services to reach their full potential in terms of benefits. The more C-ITS stations are interoperable, the bigger the C-ITS network and the earlier network effects can be accessed. Any measures impacting interoperability are expected to have direct impacts on C-ITS deployment. Under PO1 a definition of Day 1 services in guidelines and reference to existing standards is expected to improve interoperability in cases of voluntary compliance (i.e. in some local/regional areas). Limitations in the effectiveness of this measure, however, arise from its non-binding nature, which still risks that several non-interoperable systems will emerge. EU-wide interoperability is not expected be achieved and thus the impacts remain limited.

Uncertainty around compliance assessment processes hinder deploying stakeholders that want to meet voluntary standards around C-ITS services to check compliance. Guidelines on the process, roles and responsibilities will help actors to meet requirements and help harmonise C-ITS deployment. Due to the guidance being non-binding any impacts on deployment will be limited to pockets of the market and will not be comprehensive across Europe.

Continuity will be improved through a stakeholder platform to ensure coordination and policy advice. The acknowledged success of the C-ITS platform has shown how effective a platform bringing together all types of stakeholders can be. Setting up something similar going forward is expected to be an effective measure to ensure continuity across Europe. The impact of such a measure on deployment depends on the exact format of
the platform. Knowledge sharing and coordination across Europe will be an incentive for C-ITS actors to deploy the technology, however, as long as deployment is voluntary the impact is expected to be limited.

**Enabling conditions** are expected to be improved through funding of the development of future C-ITS services beyond Day 1 and 1.5 (R&I). This will have some impact on the level of deployment in Europe but there is uncertainty around the extent that R&I funding will trigger actual deployment. EU-driven MoUs between key stakeholders could help set some deployment targets, given that some MoUs in the area of C-ITS already exist (e.g. between C-Roads and the Car2Car Communication Consortium (VTS, 2017)). As MoUs are non-binding agreements, however, only a small impact on deployment beyond the baseline can be expected.

**4.4.3. Stakeholder support for Policy Option 1**

As discussed in Section 2.3, the stakeholders interviewed for the deployment case studies noted the need for further guidance on a number of topics. Policy option 1 provides that guidance through non-binding measures. The respondents requested further specifications on the GDPR to ensure that the regulation is applied correctly without restricting data sharing. They also noted the need for clearly defined C-ITS services, and the definition of common interoperability standards. Respondents also noted better coordination is also achieved through the definition of roles, and improved cooperation and enabling conditions. The C-Roads platform representative emphasised the referencing of technical standards, including basic requirements of backwards compatibility and interoperability. These measures allow the market to choose the best technologies to apply for C-ITS services by opening it to all users.

The OPC respondents confirmed that the issues covered under this policy option are of high importance, and that soft measures were largely considered to be moderately appropriate across all objectives.
4.5. **Policy Option 2**

4.5.1. **Description of measures under Policy Option 2**

PO2 includes all elements under PO1 but goes further, by bringing definitions for C-ITS services, common service profiles and compliance with C-ITS related policies into the specifications of the legally binding Delegated Act, instead of as non-binding measures. If C-ITS services are deployed, the specifications fully apply. This policy option also goes further in terms of the requirements for coordination and standardisation. The full set of measures is shown in Table 4-3, which also includes summary details on each measure.

**Table 4-3: Measures considered under Policy Option 2**

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<thead>
<tr>
<th>Privacy and protection of personal data, including access to data and data quality</th>
<th>Security</th>
<th>Interoperability</th>
<th>Compliance assessment</th>
<th>Continuity</th>
<th>Enabling conditions</th>
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</thead>
<tbody>
<tr>
<td>Requirements &amp; procedures</td>
<td>Roles/Bodies</td>
<td>Services</td>
<td>Communication specifications</td>
<td>Requirements &amp; procedures</td>
<td>Roles/Bodies</td>
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**Policy option 2: legal measures - specification s only**

- EC adopts binding application specifications for the GDPR in the context of C-ITS, including the responsibilities and requirements.
- Establishing purposes for lawfully processing personal data as traffic safety & efficiency, with limitations (no commercial or law enforcement use).
- Contents of the European Union C-ITS Security Credential Management System (EU CCMS) is put into EU law, specifying C-ITS security requirements & procedures. Possibility to update the policy, e.g. through a review clause.
- Definition of needed roles in CCMS is put into EU law, plus a requirement to provide information to the Commission on the bodies/authorities in charge, if they have been set up.
- Definition of Day 1 services list in specifications. C-ITS stations to be compatible with all Day 1 Services. Updatability of services and their definitions, e.g. through a review clause.
- Mandate compliance with existing standards on inter-operability in specifications. Mandate compliance with EU-wide service profiles of Day 1 services in specifications. Issue a mandate to EU-level standardisation organisations for standardisation of services beyond the Day 1 list.
- Define in the specifications, requirements for needed roles in relation to the approval process of C-ITS stations & information to the Commission on the bodies/authorities in charge if they have been set up.
- Define in the specifications, requirements for needed roles in relation to the approval process of C-ITS stations & information to the Commission on the bodies/authorities in charge if they have been set up.

**PO1+**

- Enhanced deployment coordination.
- Strengthened funding of deployment to enable quicker uptake, including requirements on data reporting and exchange for deployment projects receiving funding.
- Fund EU deployment coordination after current piloting phase.
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<thead>
<tr>
<th>Privacy and protection of personal data, including access to data and data quality</th>
<th>Security</th>
<th>Interoperability</th>
<th>Compliance assessment</th>
<th>Continuity</th>
<th>Enabling conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measure description</strong></td>
<td>Similar measures compared to PO1 but with more details on the practical application, including responsibilities. In addition, compliance for those deploying is now mandatory.</td>
<td>The CCMS should apply to all C-ITS services. This measure ensures that the policy included in EU law and thus mandatory. Given the fast developments in the field and the need to update the CCMS it will be key for successful deployment if the legislation allows the possibility to review.</td>
<td>This measure ensures that the needed roles as identified in the CCMS are defined in EU law.</td>
<td>Similar measure to the compliance measure under PO1 with the difference that the reference to existing standards on interoperability will be picked up in the specifications and the standards become mandatory in case of deployment.</td>
<td>Similar measure as compliance measure under PO1 with the difference that the definition of the compliance assessment process will be included in the specifications and will thus be mandatory in case of deployment.</td>
</tr>
<tr>
<td><strong>Requirements &amp; procedures</strong></td>
<td><strong>Roles/Bodies</strong></td>
<td><strong>Services</strong></td>
<td><strong>Communication specifications</strong></td>
<td><strong>Requirements &amp; procedures</strong></td>
<td><strong>Roles/Bodies</strong></td>
</tr>
</tbody>
</table>
4.5.2. Expected impact of Policy Option 2 on deployment beyond the baseline

PO2 goes beyond PO1 in terms of strength of the measures by putting specifications/requirements into EU law through a Delegated Act (instead of non-binding guidelines). While C-ITS deployment is still voluntary, any deployment has to meet the same requirements across Europe. This will have significant impacts on interoperability and continuity, however, the impacts on deployment are still indirect. More uniform rules across Europe will provide more certainty for stakeholders wanting to deploy C-ITS. It also is expected to increase user demand, through increased trust regarding privacy/protection of personal data as well as security. Both expected developments are likely to translate into higher uptake rates across Europe. In comparison to a deployment mandate (as in PO3), the level of additional uptake beyond the baseline is still limited. It is expected to encourage uptake in Member States that are currently behind in deployment, by providing a level playing field across Europe. Increased funding beyond the piloting phase will have significant impact on deployment and could help ensure the set-up of self-sustaining C-ITS systems, crucial for sustainable deployment.

The EU adopting application specifications for the GDPR can ensure more effective practical application of the GDPR for C-ITS and thus reduce barriers around privacy and protection of personal data. In addition to the benefits of the guidelines, this measure will have a stronger impact on deployment as it sets out with more certainty how personal data can be used in the context of C-ITS, by establishing purposes for lawfully processing personal data for C-ITS. The effectiveness of this measure in terms of reducing barriers around this topic is expected to be moderate, as a delegated act would not yet provide a legal basis for the processing of personal data. A stronger impact on deployment than in PO1 is expected.

Incorporating the European Union C-ITS Security Credential Management System (EU CCMS) in EU law will make it legally binding and provide a strong measure to reduce uncertainties and barriers around security, as enrolment in the CCMS is a pre-requisite needed for operation, ensuring that every C-ITS station is within the same trust domain. The same goes for the assignment of roles into EU law. Given the importance of security issues, this is expected to have a significant impact on deployment. The definition of roles and bodies on security will ensure that where such bodies are being set up, responsibilities are clear, and the Commission is informed. However, the establishment of such bodies is not mandatory in this measure, and thus relies on the voluntary set-up of such bodies. The impact of this measure is thus somewhat limited.

Interoperability will be improved under PO2 through a definition of Day 1 services in specifications and the mandated compliance with EU-wide service and system profiles are strong measures to help increase interoperability. However, without a deployment mandate this is limited to cases where C-ITS services are voluntarily deployed. Nevertheless, a sizeable impact on deployment in the EU could be expected as these measures ensure that the voluntary deployed network is interoperable, thus more attractive to C-ITS providers through providing earlier access to network benefits and ensuring backward compatibility.

The definition of the compliance assessment process in the specifications and the definition of relevant roles ensure that where C-ITS services are deployed they meet the necessary requirements. This will ensure harmonisation of deployed C-ITS services. Similar to the mechanism explained for interoperability this will be expected to increase deployment. Limitations to the impact on the overall level of deployment are down to the fact that deployment itself is not mandatory and impacts are limited to voluntary deployment initiatives.

The impact mechanisms for the measures covering continuity in PO2 are the same as in PO1, but enhanced deployment coordination will help implementation and likely result in greater impacts on deployment.
Enabling conditions under PO2 include all of the measures included in PO1 but in addition aim at strengthening the funding for C-ITS deployment and the provision of funding for deployment coordination beyond the current piloting phase; this will enable quicker uptake. The level of impact, however, will depend on the specific change in the magnitude and nature of the funding (In our scenario assumptions, we do not assume any particular level of funding). The provision of funding for EU level deployment coordination beyond the current piloting phase ensures that coordination at the commercial deployment stage, which is important for continuity of services across Europe in turn will have some indirect impacts on EU-wide deployment. The data reporting and sharing requirements are expected to significantly improve knowledge sharing and help follower countries access learning from front runner countries, thus accelerating their uptake.

4.5.3. Stakeholder support for Policy Option 2

Stakeholders interviewed for the deployment case studies supported mandating specifications for several topics to improve harmonisation and interoperability. Most agreed that a mandate for security and privacy is important, to ensure trust among all partners as to how data will be shared. Some stakeholders noted that the GDPR already provides a requirement for privacy in general, but measures under PO2 are expected to clarify the requirements and protection for C-ITS stakeholders and users.

Respondents to the Public Consultation supported using mandatory measures as described in this policy option, as they largely felt that ensuring security through common rules, practical application of data protection, and interoperability through the application of common rules is most appropriately achieved through legally binding EU specifications on C-ITS.

However, stakeholders were split on how interoperability of C-ITS should be achieved. Most stakeholder agree that common definitions and specifications of the C-ITS services themselves, and interoperability requirements for higher communication layers are needed. On the other hand, stakeholders are divided on if and how interoperability should be ensured at the level of communication technologies / hybrid communication. Some consider that clear legally binding interoperability rules are needed here to ensure that all C-ITS stations can talk to each other, while others consider that communication technologies should not be specified in legal requirements to allow for different solutions to develop. Several stakeholders also indicated the challenges with specifications based on standards in a quickly developing field, with one suggesting that the existing standards will not be enough, and another that mandating standards may be too slow to follow the development of the market.
### 4.6. Policy Option 3

#### 4.6.1. Description of measures under Policy Option 3

PO3 includes the strongest measures based on all measures in PO2 and PO1 but complementing them with a deployment mandate for Day 1 V2V services. In addition, roles for security and compliance assessment are assigned to legal bodies. It should be noted that the assignment of roles to legal bodies and the deployment mandate will require co-decision procedures outside a delegated act. Table 4-4 gives an overview of the individual measures, summary details and a qualitative assessment of their potential impacts.

**Table 4-4: Measures considered under Policy Option 3**

<table>
<thead>
<tr>
<th>Privacy and protection of personal data, including access to data and data quality</th>
<th>Security</th>
<th>Interoperability</th>
<th>Compliance assessment</th>
<th>Continuity</th>
<th>Enabling conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy option 3: legal mandate, on top of option 2</td>
<td>PO2 combined with lawfully processing data based on legal obligation or public interest.</td>
<td>Same as PO2</td>
<td>Same as PO2</td>
<td>PO2 + Assignment of roles to legal bodies.</td>
<td>PO2 + Mandatory deployment of V2V communication.</td>
</tr>
<tr>
<td>Detailed measure description</td>
<td>Similar to PO2. A co-decision following the delegated act is needed to create a legal basis.</td>
<td>-</td>
<td>This measure goes beyond a definition of roles by assigning roles to legal bodies. This requires a co-decision following the delegated act.</td>
<td>-</td>
<td>Significantly stronger measure than PO1 and PO2, as this mandates actual deployment and not only standards in the case of deployment. This requires a co-decision following the delegated act.</td>
</tr>
</tbody>
</table>
4.6.2. Expected impact of Policy Option 3 on deployment beyond the baseline

PO3 goes beyond PO2 with additional measures related to privacy/protection of personal data, security, compliance assessment and continuity. By setting up C-ITS relevant bodies, compliance and coordination across Europe are improved which results in increased uptake of C-ITS. Direct impacts on deployment stem from the in-vehicle mandate for V2V services, which are expected to be significant, unlike PO1 and PO2 where the impacts on deployment are indirect.

The introduction of a legal instrument through co-decision can introduce a legal ground for the processing of personal data related to C-ITS, which would clarify the reasons and approach to processing C-ITS messages. This will likely result in greater uptake via the provision of more C-ITS services.

The assignment of roles on security to legal bodies will ensure the necessary coordination and oversight of security issues, thus ensuring that barriers to C-ITS uptake due to security concerns are reduced to a minimum. Additional indirect (positive) impacts on deployment are expected.

The assignment of roles for compliance assessment to legal bodies will ensure harmonisation of C-ITS services across Europe, which is expected to have a reasonably significant indirect impact on deployment.

Finally, the most dominant measure for deployment is covered under continuity. Mandatory deployment of V2V communication is the strongest possible measure for V2V uptake and will significantly increase overall C-ITS deployment. High levels of uptake of V2V services are also expected to trigger enhanced C-ITS infrastructure deployment, because the guaranteed uptake in vehicles will increase the certainty and attractiveness of infrastructure investments.

4.6.3. Stakeholder support for Policy Option 3

The stakeholders interviewed for the deployment case studies were not asked to comment on the possibility of mandatory deployment of V2V communications. However, the international case studies show that Japan has had success from mandatory deployment, and the U.S. proposed a mandate for V2V communications deployment based on the safety benefits identified. One deployment case study respondent also felt that mandating mature technologies will increase deployment, and that mandating safety-critical features would help build a stronger business case for C-ITS. For this reason, the V2V mandate covers Day 1 services, which are safety-critical. However, other respondents noted that mandating technologies can be difficult given the pace of technological change in the industry, and the lack of agreement on which communications technology to use. While the mandate under PO3 is for V2V deployment, it does not specify which technology should be deployed, as long as it is interoperable.

Stakeholders interviewed for the deployment case studies were also supportive of the establishment of EU governance, policy and operational bodies, as this was considered important in coordinating deployment across Europe. They largely felt that the C-Roads Platform is helping in this regard, but as deployment continues this will need to be formalised by legal bodies.

Respondents to the Public Consultation supported mandating C-ITS equipment in new vehicles, with 43 out of 132 agreeing, and another 41 strongly agreeing. There was little differentiation in this view across stakeholder groups.
4.7. **Uptake assumptions and uptake for policy options under consideration**

In this section, we summarise the various assumptions and consequent uptake rates for deployment in new vehicles, personal C-ITS devices, and infrastructure.

These have been developed with a close consideration of the impact mechanisms of the policy option measures, which are described in the sections above. As most of the impacts are indirect, the deployment rates have been established through an iterative process that began by considering the scenarios used in the 2016 C-ITS deployment study (Ricardo, 2016), which were the result of significant expert input from Working Group 1 during Phase I of the C-ITS platform. These were further developed based on available literature and finally verification at the February 2018 stakeholder workshop.

The deployment of C-ITS uptake into new vehicles across Policy Options and vehicle types has been reflected in numbers of vehicle full-model and facelift cycles, as it is through these updates that C-ITS technology will enter the vehicle fleet. Full model cycles involve vehicle redesigns. Personal transport vehicles are assumed to have full model cycles of 7 years\(^{29}\) and public & freight transport are assumed to have longer cycles of 9 years. These model lifecycles were presented and validated at the stakeholder workshop. Facelift cycles occur between full-model redesigns and comprise minor upgrades to vehicle functionality and styling that occur midway through a model’s full model cycle to keep market interest in the vehicle high. Personal transport vehicles are assumed to have facelift cycles of 4 years and public & freight transport are assumed to have longer facelift cycles of 5 years.

### 4.7.1. **Uptake assumptions and uptake for ITS sub-systems in new vehicles**

Table 4-5 presents the uptake assumptions and Figure 4-1 shows how these translate into uptake over time for each policy option.

**Table 4-5: Policy Options – Uptake assumptions for ITS sub-systems in new vehicles**

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal Transport</strong></td>
<td>Same assumptions as baseline but with faster uptake. Maximum penetration reached after 4 full model cycles, starting 2019. (4x7 years = 28 years)</td>
<td>Maximum penetration reached in the same number of cycles (4) as PO1 but now using vehicle facelift cycles, starting 2019 (i.e. shorter cycle length of four years: 4x4 years = 16 years).</td>
<td>Uptake rates reflect mandate, reaching all cars in one full model cycle, starting in 2021.</td>
</tr>
<tr>
<td><strong>Public Transport &amp; Freight</strong></td>
<td>Same uptake assumptions as personal transport but with longer model cycles, starting 2019. (4x9 years = 36 years)</td>
<td>Same uptake assumptions as personal transport but with longer facelift cycles, starting 2019. (4x5 years = 20 years)</td>
<td>All vehicles covered by 2030, starting 2021 (1 full model cycle).</td>
</tr>
</tbody>
</table>

**Key assumptions and inputs:**

\(^{29}\) Assumed value substantiated by analysis of the generation model cycles of 16 personal vehicles (4 from each car category: A/B,C,D,E/F). Values of 7 years for cars and 9 years for freight were agreed as reasonable by stakeholders at the workshop.
In PO1, the combination of measures will result in greater user acceptance of services and provide more clarity for C-ITS providers resulting in increased uptake relative to the baseline. However, the majority of policies are non-binding guidelines and so deployment is restricted to where these guidelines are voluntarily applied. This is the option with the highest degree of uncertainty concerning the projected uptake. A conservative uptake duration of 4 full model cycles is assumed, supported by stakeholder feedback that it should be close to the baseline (where 5 model cycles is assumed).

In PO2, it is assumed that C-ITS services can be delivered in new vehicles mid-model cycle, during their facelift cycles. This is due to defined specifications encouraging greater coordination, standardisation and confidence. Stakeholders at our February 2018 workshop agreed that it was reasonable to assume that C-ITS technology could be introduced mid-lifecycle.

The only available literature to substantiate future C-ITS uptake were research forecasts by Visiongain/IHS market, for ITS-G5 and LTE-V2X respectively (Visiongain, 2016) (IHS Automotive, 2016) (IHS Markit, 2014). After an analysis by the study team and consultation with stakeholders these assumptions were considered to be too optimistic for the EU baseline when compared to the 2016 C-ITS study baseline developed after literature reviews and expert consultations. Instead, the Visiongain/IHS scenario was used as a basis to develop PO2.

It is assumed that a mandate in PO3 would not be introduced until 2021, given the common lead-in time for such a mandatory measure.

It is assumed that uptake rates in new vehicles are the same across all countries, although penetration into the fleet differs by Member State due to different rates of fleet renewal.

Figure 4-1: Uptake of C-ITS sub-systems in new personal vehicles in the Policy Options compared to baseline

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30 It is likely that the Visiongain projections only considered vehicle equipment, but not interoperable vehicle equipment. For this reason, we considered it too optimistic as a basis for the baseline.
4.7.2. **Uptake assumptions and uptake for personal C-ITS devices for policy options under consideration**

The only personal C-ITS devices modelled in this study are smartphones, for the reasons explained earlier. The scope of uptake of C-ITS bundles does not change from the baseline presented in Section 3. The key difference between policy options is in the speed of deployment, which mirrors the speed of deployment in new vehicles detailed in Section 4.7.1. Moreover, in the policy options, like the baseline, uptake in personal C-ITS devices will start when C-ITS system penetration in new vehicles starts. Feedback from an expert group meeting highlighted that C-ITS can already be provided by mobile phones and so it is reasonable to assume that uptake will at least begin in line with new vehicle C-ITS sub-system uptake. This is seen as a neutral assumption in the absence of data to support an assumption that deployment in personal C-ITS devices will be slower or faster than uptake in new vehicles. Personal C-ITS device uptake increases linearly, to a maximum uptake of 95 percent when in-vehicle systems reach 100 percent.

4.7.3. **Uptake assumptions and uptake for infrastructure for policy options under consideration**

Infrastructure assumptions and resulting uptake are defined by country group. In this section we present the assumptions and uptake for Front Runner countries (see Table 4-6 and Figure 4-2 and Figure 4-3. Assumptions and uptake rates for Followers and Planned Adopters are displayed in Annex B – Section 3. The key difference for these groups is the delay in uptake, although they will have similar uptake rates as the Front Runners in the policy options, as the same framework conditions will apply.

**Table 4-6: Policy Options – Uptake assumptions for infrastructure in Front Runners**

<table>
<thead>
<tr>
<th>Road type</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEN-T Corridor</td>
<td><strong>RSU</strong>: Use actual data on average deployment levels expected to be achieved by 2020. From 2020, project the trajectory at <strong>25%</strong> of the deployment rate between 2015 and 2020. <strong>Cellular</strong>: assume an 84% coverage</td>
<td><strong>RSU</strong>: Use actual data on average deployment levels expected to be achieved by 2020. From 2020, project the trajectory at the <strong>same rate</strong> as deployment rate between 2015 and 2020. <strong>Cellular</strong>: assume an 84% coverage</td>
<td><strong>RSU</strong>: Use actual data on average deployment levels expected to be achieved by 2020. From 2021, project the trajectory at <strong>150%</strong> of the deployment rate between 2015 and 2020, triggered by the in-vehicle mandate. <strong>Cellular</strong>: assume an 84% coverage</td>
</tr>
<tr>
<td>TEN-T Core</td>
<td><strong>RSU</strong>: No uptake</td>
<td><strong>RSU</strong>: From 2020, project the uptake rate of TEN-T Corridor and Core roads at <strong>50% of the uptake rate</strong>. <strong>Cellular</strong>: assume an 84% coverage</td>
<td></td>
</tr>
<tr>
<td>Other Motorways (TEN-T Comprehensive)</td>
<td><strong>RSU &amp; Cellular</strong>: 8% (traffic light stock that is replaced each year) x 50% (new traffic lights equipped) per year from 2020</td>
<td><strong>RSU</strong>: From 2020, project the uptake rate of TEN-T Corridor and Core roads at <strong>25% of the uptake rate</strong>. <strong>Cellular</strong>: assume an 84% coverage</td>
<td></td>
</tr>
<tr>
<td>Non-Urban Non-Motorway</td>
<td><strong>RSU &amp; Cellular</strong>: 8% x 75% per year from 2020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td><strong>RSU &amp; Cellular</strong>: 8% x 75% per year from 2020</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Key assumptions and inputs:

- From PO2, RSU uptake is applied to the wider road network, but at reduced rates relative to TEN-T Corridor/Core uptake.
- Activity is expected to be focused on TEN-T corridor and core roads in the policy options, with diminishing activity for smaller roads.
- The increased infrastructure uptake in PO3 starts in 2021, in line with the mandate for penetration in new vehicles - which is expected to trigger additional infrastructure uptake, because the guaranteed uptake in vehicles will increase the certainty and attractiveness of infrastructure investments.
- The uptake of central C-ITS systems is the modelled in the same way as the baseline.

Figure 4-2: Uptake of RSU infrastructure in TEN-T Corridor/Core roads of Front Runners

Figure 4-3: Uptake of RSU infrastructure for Front Runners across all Policy Options
4.7.4. **Impacts on deployment**

C-ITS uptake/deployment is the key parameter influencing the level of modelled indirect impacts in Section 5.2. Table 4-7 below provides a snapshot of the annual deployment figures for new vehicles equipped with C-ITS in 2030 and 2035 under each of the policy options, with changes relative to the baseline in those years.

**Table 4-7: Annual new vehicle deployment relative to the baseline for EU 28 – 2030/2035**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>% change from baseline in 2030</th>
<th>Additional deployment relative to the baseline in 2035</th>
<th>% change from baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO1</td>
<td>1.3 mn</td>
<td>25%</td>
<td>2.0 mn</td>
<td>25%</td>
</tr>
<tr>
<td>PO2</td>
<td>6.4 mn</td>
<td>119%</td>
<td>9.6 mn</td>
<td>119%</td>
</tr>
<tr>
<td>PO3</td>
<td>12.1 mn</td>
<td>228%</td>
<td>10.2 mn</td>
<td>126%</td>
</tr>
</tbody>
</table>
Figure 4-4 shows the total cumulative vehicle deployment relative to the baseline. The figures take into account vehicle scrappage\textsuperscript{31}, and so the cumulative figures represent the total number of new vehicles fitted with C-ITS in the fleet.

**Figure 4-4: Total cumulative new vehicles deployed and in service, relative to baseline for EU 28**

![Diagram showing cumulative vehicle deployment](image)

Table 4-8 and Table 4-9 below show these cumulative new vehicle deployments in greater detail, with absolute new vehicles deployed, the percentage of the fleet equipped, and the difference relative to the baseline. The table shows aggregate figures from 2020. This is because PO1 and PO2 both begin in 2019, but there are no impacts until 2020. The V2V mandate of PO3 begins in 2021; it follows PO2 uptake prior to 2021. All three policy options result in increased vehicle deployment compared to the baseline, with PO3 delivering the greatest levels of additional deployment over the period to 2035.

Policy Option 1 (PO1) has the slowest deployment profile. By 2030, additional cumulative deployment relative to the baseline is 7.8 million, a 25 percent increase of the baseline in that year. By 2035, total cumulative deployment in new vehicles reaches 76.9 million, an increase of 15.4 million relative to the baseline. This also represents a 25 percent increase over the baseline.

Policy Option 2 (PO2) sees a significant increase relative to PO1, with 37.5 million cumulative new vehicles equipped by 2030, a 119 percent increase from the baseline. By 2035, cumulative new vehicles equipped reach 135.0 million. This is an additional cumulative 73.5 million vehicles equipped over the baseline, a 120 percent increase.

\textsuperscript{31}The average lifetime of all new vehicles across the EU has been estimated to be 12 years, based on the EasyWay and COBRA studies (EasyWay Cooperative Systems Task Force, 2012; TNO, 2013). While deployment of new vehicles including those scrapped at the end of the model period is used to calculate one-off equipment costs incurred over the period, annual costs for C-ITS in new vehicles are based on the number of vehicles in service in each year of the model period and exclude vehicles that have been scrapped.
Policy Option 3 (PO3) offers the largest increase in new vehicle equipment, 78.9 million new vehicles equipped by 2030, an increase of 251 percent over the baseline. By 2035, an estimated 186.7 million new vehicles will be equipped, a 125.2 million increase over the baseline. This represents a 204 percent increase from the baseline.

By 2035, additional deployment relative to the baseline under PO2 is nearly five times that of PO1 – a very significant increase. The difference between deployment in 2035 for PO2 and PO3 is not as large – PO3 deployment represents about 1.7 times that of PO2 by 2035. Another significant difference is the share of the vehicle fleet equipped. Table 4-9 shows that this is 23 percent for PO1, 40 percent for PO2 and 55 percent in PO3 by 2035.

Table 4-8: Cumulative new vehicles deployed and in service, difference relative to the baseline and share of EU-28 fleet from 2020-2030

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>% share of fleet (EU28 average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>31.4 mn</td>
<td>-</td>
<td>10%</td>
</tr>
<tr>
<td>PO1</td>
<td>39.2 mn</td>
<td>7.8 mn</td>
<td>12%</td>
</tr>
<tr>
<td>PO2</td>
<td>68.8 mn</td>
<td>37.5 mn</td>
<td>21%</td>
</tr>
<tr>
<td>PO3</td>
<td>110.3 mn</td>
<td>78.9 mn</td>
<td>34%</td>
</tr>
</tbody>
</table>

Table 4-9: Cumulative new vehicles deployed and in service, difference relative to the baseline and share of EU-28 fleet from 2020-2035

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2035</th>
<th>Additional deployment relative to the baseline in 2035</th>
<th>% share of fleet (EU28 average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>61.5 mn</td>
<td>-</td>
<td>18%</td>
</tr>
<tr>
<td>PO1</td>
<td>76.9 mn</td>
<td>15.4 mn</td>
<td>23%</td>
</tr>
<tr>
<td>PO2</td>
<td>135.0 mn</td>
<td>73.5 mn</td>
<td>40%</td>
</tr>
<tr>
<td>PO3</td>
<td>186.7 mn</td>
<td>125.2 mn</td>
<td>55%</td>
</tr>
</tbody>
</table>

Table 4-10 shows the total number of new vehicles that have been deployed with C-ITS in the periods 2020-2030 and 2020-2035. Unlike Table 4-8 and Table 4-9, these figures do not consider any scrappage of vehicles within the fleet over the model period.

Table 4-10: Total new vehicles deployed in EU-28 between 2020-2030 and 2020-2035, and difference relative to the baseline

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>2035</th>
<th>Additional deployment relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>31.4 mn</td>
<td>-</td>
<td>66.1 mn</td>
<td>16.5 mn</td>
</tr>
<tr>
<td>PO1</td>
<td>39.2 mn</td>
<td>7.8 mn</td>
<td>82.6 mn</td>
<td>79.0 mn</td>
</tr>
<tr>
<td>PO2</td>
<td>68.8 mn</td>
<td>37.5 mn</td>
<td>145.2 mn</td>
<td>133.8 mn</td>
</tr>
<tr>
<td>PO3</td>
<td>110.3 mn</td>
<td>78.9 mn</td>
<td>199.9 mn</td>
<td>133.8 mn</td>
</tr>
</tbody>
</table>

Table 4-11 shows the annual deployment trends in personal C-ITS devices for 2030 and 2035 relative to the baseline. These show that as the policy options progress from 2030 to 2035, fewer devices are equipped relative to the baseline. This is due to greater in-
vehicle deployment over time. Moreover, this effect appears earlier in PO3 due to the V2V mandate, which means fewer non-equipped vehicles enter the market.

**Table 4-11: Annual personal C-ITS device deployment relative to the baseline for EU 28 – 2030/2035**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>% change from baseline in 2030</th>
<th>Additional deployment relative to the baseline in 2035</th>
<th>% change from baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO1</td>
<td>0.9 mn</td>
<td>14%</td>
<td>-0.2 mn</td>
<td>-3%</td>
</tr>
<tr>
<td>PO2</td>
<td>2.0 mn</td>
<td>30%</td>
<td>-4.9 mn</td>
<td>-93%</td>
</tr>
<tr>
<td>PO3</td>
<td>-5.5 mn</td>
<td>-83%</td>
<td>-5.3 mn</td>
<td>-100%</td>
</tr>
</tbody>
</table>

Figure 4-5 below shows the additional cumulative deployment of personal C-ITS devices relative to the baseline. As with the annual figures presented above, deployment of personal C-ITS devices falls over time, so by 2035 deployment is lower. Under PO1, C-ITS equipped devices will reach 19.9 million by 2035 in addition to the baseline. By 2030, that figure is 18.2 million. Under PO2, uptake is higher, reaching 64.8 million by 2035 relative to the baseline. In 2030, that figure is 76.6 million. Uptake is highest under PO3, peaking in 2028 – a year after 100 percent of the new vehicle fleet is equipped under PO3. The deployment drops off steeply thereafter relative to the baseline. This results from a peak in the percentage of personal C-ITS devices deployed in vehicles, combined with a continued decrease in the size of the fleet available for personal C-ITS device deployment as new equipped vehicles continue to enter the market. By 2035, uptake is 16.7 million relative to the baseline (116.8 million by 2030).

**Figure 4-5: Total cumulative personal C-ITS device deployment relative to baseline for EU28**

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32 Our model does not assume a lifetime for smartphones – as it assumes that people will own a smartphone regardless of using C-ITS, which may or may not be equipped with C-ITS depending on the penetration by policy option. Further, as in-vehicle equipment progresses, we model that smartphones will no longer be used as personal C-ITS devices once a consumer’s vehicle is equipped.
Table 4-12 below summarises the absolute cumulative deployment of in service personal C-ITS devices between 2020 and 2030, as well as 2020-2035. It also shows the additional deployment relative to the baseline in 2030 and 2035.

**Table 4-12: Cumulative personal C-ITS device deployed and in service, and the difference relative to the baseline for EU28 – 2030/2035**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>2020-2035</th>
<th>Additional deployment relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>84.3 mn</td>
<td>-</td>
<td>114.4 mn</td>
<td>-</td>
</tr>
<tr>
<td>PO1</td>
<td>102.5 mn</td>
<td>18.2 mn</td>
<td>134.3 mn</td>
<td>19.9 mn</td>
</tr>
<tr>
<td>PO2</td>
<td>160.9 mn</td>
<td>76.6 mn</td>
<td>177.9 mn</td>
<td>63.4 mn</td>
</tr>
<tr>
<td>PO3</td>
<td>201.2 mn</td>
<td>116.9 mn</td>
<td>131.2 mn</td>
<td>16.7 mn</td>
</tr>
</tbody>
</table>

Note: Numbers are rounded to the nearest 100,000.

For new roadside unit deployment (RSU), which are used for short-range communication, Table 4-13 below shows a snapshot of annual deployment figures in 2030 and 2035, with the change relative to the baseline under the policy options. PO2 and PO3 represent a significant increase from the baseline in 2030. In 2035, the baseline values are zero for new RSU deployment, so the percent increase cannot be calculated.

**Table 4-13: Annual new RSU deployment relative to the baseline for EU 28 – 2030/2035**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>% change from baseline in 2030</th>
<th>Additional deployment relative to the baseline in 2035</th>
<th>% change from baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO1</td>
<td>600</td>
<td>48%</td>
<td>1,300</td>
<td>n.a.</td>
</tr>
<tr>
<td>PO2</td>
<td>7,500</td>
<td>559%</td>
<td>14,200</td>
<td>n.a.</td>
</tr>
<tr>
<td>PO3</td>
<td>10,900</td>
<td>814%</td>
<td>18,100</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

Figure 4-6 shows cumulative new RSU deployment under the policy options relative to the baseline. These figures use a 10-year lifetime for RSUs (RSUs are replaced at the end of their lifetime). Deployment is lowest under PO1, reaching 13,000 RSUs by 2035. This figure is 6,000 in 2030. Under PO2, deployment increases significantly, reaching 134,000 units by 2035 (67,000 by 2030). PO3 represents an additional increase from PO2 – this represents the demand for infrastructure deployment induced by the V2V mandate under PO3. Under PO3, new units reach 181,000 by 2035 (97,000 by 2030).

33 In the baseline, it is assumed that new infrastructure deployment takes place from 2020 (the end of the C-Roads project), aside from replacement of RSU units after the 10-year lifetime has expired. For this reason, there is a baseline value in 2030 (replacement of units), but not 2035.
Table 4-14 below shows the absolute numbers for cumulative new RSU deployments as well as the difference relative to the baseline for the years 2020-2030 and 2020-2035. There is a large gap between new units under PO1 and PO2, representing a more than five-fold increase for 2020-2030 and nearly seven-fold increase for 2020-2035. The increase between PO2 and PO3 is far less pronounced – a 45% increase for 2020-2030 and a 33% increase for 2020-2035.

Table 4-14: Cumulative new RSU deployment and difference relative to the baseline for EU28 – 2030/2035

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>2020-2035</th>
<th>Additional deployment relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>8,000</td>
<td>-</td>
<td>8,000</td>
<td>-</td>
</tr>
<tr>
<td>PO1</td>
<td>14,000</td>
<td>6,000</td>
<td>21,000</td>
<td>13,000</td>
</tr>
<tr>
<td>PO2</td>
<td>75,000</td>
<td>67,000</td>
<td>142,000</td>
<td>134,000</td>
</tr>
<tr>
<td>PO3</td>
<td>105,000</td>
<td>97,000</td>
<td>189,000</td>
<td>181,000</td>
</tr>
</tbody>
</table>

Note: Numbers are rounded to the nearest 1,000.

In addition to new RSU deployment, we also model upgraded RSU deployment. These trends represent retrofitted roadside units, as opposed to the new RSU units described above. Table 4-15 shows a snapshot in 2030 and 2035 under each policy option with the difference relative to the baseline (in percentage terms). PO2 and PO3 share the same trend line, by assuming that the V2V mandate in PO3 only triggers new RSU unit deployment, rather than retrofitted units and other infrastructure assets.
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Table 4-15: Annual upgraded RSU deployment relative to the baseline for EU 28 – 2030/2035

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>% change from baseline in 2030</th>
<th>Additional deployment relative to the baseline in 2035</th>
<th>% change from baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO1</td>
<td>5,100</td>
<td>243%</td>
<td>10,200</td>
<td>243%</td>
</tr>
<tr>
<td>PO2</td>
<td>8,700</td>
<td>414%</td>
<td>17,400</td>
<td>414%</td>
</tr>
<tr>
<td>PO3</td>
<td>8,700</td>
<td>414%</td>
<td>17,400</td>
<td>414%</td>
</tr>
</tbody>
</table>

Figure 4-7 shows the total additional cumulative RSU upgrades relative to the baseline for the policy options. By 2035, retrofitted units reach 81,000 under PO1 (41,000 by 2030). For PO2/PO3, retrofitted units reach 142,000 by 2035 (71,000 by 2030).

Figure 4-7: Total cumulative RSU upgrade relative to baseline for EU28

![Graph showing cumulative RSU upgrades]

Table 4-16 below shows the absolute numbers for cumulative additional RSU upgrades as well as the difference relative to the baseline for the years 2020-2030 and 2020-2035. As with the figures in the chart above, PO2 and PO3 have the same values here (by assumption). There is an approximate 1.5-fold increase from PO1 to PO2/PO3 by 2035.

Table 4-16: Cumulative RSU upgrades and difference relative to the baseline for EU28– 2030/2035

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>2020-2035</th>
<th>Additional deployment relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>20,000</td>
<td>-</td>
<td>40,000</td>
<td>-</td>
</tr>
<tr>
<td>PO1</td>
<td>60,000</td>
<td>41,000</td>
<td>121,000</td>
<td>81,000</td>
</tr>
<tr>
<td>PO2</td>
<td>91,000</td>
<td>71,000</td>
<td>181,000</td>
<td>142,000</td>
</tr>
<tr>
<td>PO3</td>
<td>91,000</td>
<td>71,000</td>
<td>181,000</td>
<td>142,000</td>
</tr>
</tbody>
</table>

Note: Numbers are rounded to the nearest 1,000.
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Figure 4-8 below shows cumulative central ITS sub-system infrastructure deployment relative to the baseline for the policy options. As with RSU upgrades, PO2 and PO3 have the same deployment patterns (by assumption). Under PO1, central units reach 370 units by 2035 (220 by 2030). The deployment of central infrastructure units increases slightly to 440 by 2035 under PO2/PO3 (280 by 2030).

**Figure 4-8: Total cumulative central ITS sub-system infrastructure deployment relative to baseline for EU28**

Table 4-17 below shows the absolute numbers of cumulative central ITS systems deployed by scenario for 2020-2030 and 2020-2035. It also summarises the difference relative to the baseline. Through 2030, PO1 offers a slight increase in central system deployment, while PO2/PO3 show a slightly larger increase than PO1. Through 2035, however, PO1 deployment is more than double that of the baseline. In the same period, PO2/PO3 also shows a small additional uplift from PO1.

**Table 4-17: Cumulative central ITS systems and difference relative to the baseline for EU28 – 2030/2035**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>2020-2035</th>
<th>Additional deployment relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>200</td>
<td>-</td>
<td>320</td>
<td>-</td>
</tr>
<tr>
<td>PO1</td>
<td>410</td>
<td>210</td>
<td>690</td>
<td>370</td>
</tr>
<tr>
<td>PO2</td>
<td>480</td>
<td>280</td>
<td>760</td>
<td>440</td>
</tr>
<tr>
<td>PO3</td>
<td>480</td>
<td>280</td>
<td>760</td>
<td>440</td>
</tr>
</tbody>
</table>

Table 4-18 below shows the annual additional numbers of central ITS. In each of the policy options, by 2030 and 2035 the number of systems deployed is the same.
Table 4-18. Annual additional central ITS and difference relative to the baseline - 2030/2035

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2030</th>
<th>Additional deployment relative to the baseline in 2030</th>
<th>2035</th>
<th>Additional deployment relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>21</td>
<td>-</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>PO1</td>
<td>56</td>
<td>35</td>
<td>56</td>
<td>26</td>
</tr>
<tr>
<td>PO2</td>
<td>56</td>
<td>35</td>
<td>56</td>
<td>26</td>
</tr>
<tr>
<td>PO3</td>
<td>56</td>
<td>35</td>
<td>56</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 4-19 shows a summary of the deployment under each policy option as it increases from Policy Option 1 to Policy Option 3.

Table 4-19. Summary of deployment for each policy option relative to the baseline

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deployment Summary</td>
<td>Small positive impacts. Between 2020 and 2035, an extra 35.3 million vehicles (new vehicles plus retrofits via personal C-ITS devices) and 94,000 RSUs equipped relative to the baseline.</td>
<td>Significant positive impacts. Between 2020 and 2035, an extra 137.0 million vehicles (new vehicles plus retrofits via personal C-ITS devices) and 276,000 RSUs equipped relative to the baseline.</td>
<td>Very significant deployment due to V2V mandate. Between 2020 and 2035, an extra 141.9 million vehicles (new vehicles plus retrofits via personal C-ITS devices) and 322,000 RSUs equipped relative to the baseline.</td>
</tr>
</tbody>
</table>
5. **ANALYSIS OF IMPACTS**

5.1. **Direct impacts**

The following sections assess the direct impacts of the policy options on six key themes that relate back to the root causes identified in the problem definition.

5.1.1. **Impacts on privacy and protection of personal data**

Section 2.3.3 described more detail root cause #3 - 'uncertainty on how to comply with rules on privacy and protection of personal data'. Data broadcast by C-ITS services from vehicles often qualify as personal data, as these can be directly linked to the vehicle and indirectly to the identity of the vehicle owner; consequently, the General Data Protection Regulation (GDPR) will apply. However, compliance regarding privacy and the protection of personal data remain unclear and may hinder the successful deployment of C-ITS, particularly if it adversely affects trust in C-ITS.

A majority of respondents to the public consultation supported ensuring the practical application of data protection in the area of C-ITS as being one of the most important objectives to address in the proposed Delegated Act under Policy Option 2 (see Figure E-15 of the PC analysis). There was also strong support for the objective in relation to data protection being achieved at the EU level (see Figure E-18). Action on security in the context of the Delegated Regulation should also contribute to improving privacy and data protection for C-ITS users as it provides for a trusted system based on pseudonymisation of data.

Regarding the non-binding applications for the GDPR in the context of C-ITS under **Policy Option 1**, the provision of the guidelines would clarify for those deploying C-ITS, how to comply with the provisions of the GDPR (which are general and not specific to C-ITS usage). Supporting this principle was the C-Roads Platform interviewee, who believes that while the GDPR was already enough of a mandate, more guidance was needed on what safety data could be lawfully processed. Non-binding guidelines are a low-cost intervention that will have some impact on data privacy as a barrier to C-ITS deployment as it will remove uncertainty. This will help C-ITS service providers to have more clarity on how personal data can be used in the context of C-ITS.

Instead of non-binding guidelines as in the previous option, **Policy Option 2** considers the Commission adopting binding application specifications. Binding specifications around the GDPR will significantly improve clarity around the use of private data. This might encourage businesses to join the market since further uncertainties around how the GDPR is applied to C-ITS is removed. It also helps ensure consistency across all C-ITS providers in compliance, as these specifications are now binding. This measure is expected to increase user acceptance (since the rules will be uniform and compliance mandatory for service provisions) – thus user demand will increase.

Another measure under PO2 is establishing purposes (i.e. traffic safety & efficiency) for the lawful processing of data with limitations as part of C-ITS services. In addition to the benefits of the guidelines, this measure will have a stronger impact on deployment as it would define how personal data can be used in the context of C-ITS. The effectiveness of this measure is expected to be moderate in counteracting the uncertainty for compliance on the privacy and protection of personal data.

**Policy Option 3** foresees the introduction of a legal instrument through co-decision which can introduce a legal ground for the processing of personal data related to C-ITS, which would clarify the reasons and approach to processing C-ITS messages. This would further dispel uncertainties over Policy Option 1 and 2 for C-ITS service providers and users around the privacy and protection of personal data.

In summary, Policy Option 1 is likely to have small positive impacts. The provision of guidance on the GDPR in the context of C-ITS will help remove some of the uncertainties relating to the lack of clarity surrounding privacy and protection of data (currently
limiting the trust of end-users in C-ITS services, and subsequently uptake). This will be more pronounced for Policy Option 2 where binding application specifications for the GDPR in the context of C-ITS are adopted by the Commission. However, the GDPR is applicable regardless of any guidance and when fully implemented should remove concerns around privacy and protection of personal data. Therefore, the additional impact on deployment compared to the baseline is expected to be small for Policy Option 1 and Policy Option 2 under these measures.

Further positive impacts on uncertainties regarding privacy and protection of personal data are expected in PO2 as this policy option establishes the purposes for lawful processing of personal data as traffic safety and efficiency. This will have a significant impact on deployment as it sets out how exactly personal data can be used in the context of C-ITS. While there are still limitations for the use of data i.e. cannot be used for commercial or law enforcement use, the basic purpose of C-ITS (improve traffic efficiency and road safety) can be achieved and the effectiveness of this measure is expected to be high. One stakeholder highlighted that the challenges of earmarking data for specific purposes might lead to difficulties, however, C-ITS data for safety/traffic efficiency should be distinguished relatively easily from other purposes and in reality is unlikely to be a strong barrier.

Policy Option 3 is likely to have the greatest impact on privacy and protection of personal data compared to the baseline. Policy Option 3 includes lawfully processing data based on legal obligation or public interest and provides a legally binding definition for the practical application of data protection.

Table 5-1 provides a summary of the impacts for each policy option relative to the baseline for impacts on privacy and protection of personal data.
### Summary of impacts on uncertainties regarding privacy and protection of personal data for each policy option relative to the baseline

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on privacy and protection of personal data</td>
<td>Provision of guidance removing some of the uncertainties, leading to small uptake and deployment increase.</td>
<td>Provision of application specifications removing some of the uncertainties, leading to small uptake and deployment increase. Establishment of purposes for lawfully processing personal data for traffic safety and efficiency with significant impact on removing uncertainties.</td>
<td>Lawfully processing data, leading to greater uptake and deployment – helping to create attractive business models.</td>
</tr>
</tbody>
</table>

**Key:**

- **Significant positive impact**
- **Small positive impact**
- **Negligible/Neutral**
- **Small negative impact**
- **Significant negative impact**

### 5.1.2. Impacts on security

The topic of security is closely linked to the previous issue – privacy and personal data. As the transport system becomes more and more digitised, it may also become more vulnerable to hacking and cyber-attacks. Secure and trusted communication of messages exchanged between vehicles and infrastructure will therefore be important for a successful deployment of C-ITS services. Without clear rules, adopted at the EU level, the development of security solutions will be fragmented and could put interoperability and the safety of end-users at risk. Section 2.3.2 described root cause #2 – ‘barriers to establish the necessary trust with regard to cyber security of C-ITS communications’. One of the barriers to C-ITS deployment and uptake across the EU is the lack of trust in relation to cyber security. Therefore, barriers and uncertainties, including those concerning security need to be reduced in order to enable large-scale deployment of C-ITS.

Public Consultation (PC) responses confirmed that low confidence in cyber security is seen as a driver of the current problem by a majority of respondents (see Figure E-12 of the PC analysis in Annex E). The C-ITS Platform’s proposed security policy has been accepted by all of the experts involved and it was agreed that there should be a central authority for handling the security keys. The C-Roads Platform is currently working with the C-Roads projects and Member States on the implementation of security, certification and privacy in C-ITS (which are all linked), and noted that it has a dedicated task force to
deal with security issues. In some cases, national bodies have been involved in some deployment projects to ensure that security was appropriate and in line with national requirements.

It is anticipated that PO2 and PO3 are likely to have a positive effect on removing barriers to establish the necessary trust in the security of C-ITS communications (relative to the baseline), and subsequently lead to an increase in EU deployment.

The measures relating to security under **Policy Option 1** only include non-binding guidelines on the Common European C-ITS Certificate & Security Policy and governance structures/bodies needed for security. The non-binding nature of the measures limits their effect on removing barriers for security. This is because any instance of non-compliance with the required minimum standard would affect the performance of the entire system. This was also corroborated by the interviewed stakeholders. The common view was that in a first step guidance would be enough but ultimately a common security solution must be developed for all countries and become mandatory.

The definition of Security and Certificate policy in specifications, thus becoming mandatory where C-ITS is being deployed, is expected to be a more appropriate measure (as set out in **Policy Option 2**), as guidelines alone would be too weak. Mandating compliance with minimum security requirements removes key barriers to trust in providing C-ITS services by establishing a common trust domain for C-ITS stations. For example, adherence to security standards by all C-ITS stations means that the authenticity of messages sent between stations can be guaranteed – ensuring interoperability between stations and services. Mandated requirements would then improve the trust of C-ITS users in the system - improving the performance of the overall system. This is further supported by PC respondents, a majority of which considered legally binding EU specifications to be the most appropriate action to ensure security (see Figure E-21 of the PC analysis).

Operational functions and governance roles, an additional measure under PO2, will provide additional clarity on the authorities for decision making and oversight that are set up, further removing barriers for establishing the necessary trust for cyber-security. However, the fact that these roles are voluntary limits the effectiveness of the measure and may lead to some differences between Member States who do establish bodies and those who do not.

Assigning security roles to legal bodies (**Policy Option 3**) will result in the highest impact, with regards to coordination across Europe and compliance with security requirements. Assigning these roles however, will require a co-decision procedure and thus technical/legal feasibility is critical.

In conclusion, Policy Option 1 is expected to have the lowest impact of the three policy options. Non-binding guidelines will be produced by the EC on Common European C-ITS Certificates Policy (CP) and Security Policy (SP) document contents (as introduced in Section 2.3.2). Guidance on governance structure/bodies needed for security will be provided, with recommendations to assign roles to bodies. However, as the guidance is non-binding, impacts are expected to be negligible relative to the baseline, where these polices are already in place.

The Security Policy and Certificate Policy would be put into EU law under Policy Option 2, specifying C-ITS security requirements and procedures. They will apply to all C-ITS services and will become legally binding. Definitions of the required roles for CP/SP will also be put into EU law, including a requirement to provide information to the Commission on the bodies/authorities in charge, if they have been set up. The approach taken under PO2 to incorporate CP and SP in EU law will make them legally binding, creating a strong measure to reduce deployment barriers related to security. This is also the case for the assignment of roles into EU law. It is expected that this approach will have a significant impact on deployment, given the importance of security issues as barriers for deployment.
As a result of all the work that has taken place on security policy, and the inclusion of security as a focus of the C-ITS Delegated Regulation, making this a common EU-wide approach in some form or another, the Delegated Act under Policy Option 2 will significantly contribute to improving the security of C-ITS applications. Where security issues are addressed for C-ITS which results in increased trust in security, then this is likely to pave the way for automated vehicle development, deployment and uptake in the EU.

Policy Option 3 builds upon Policy Option 2 through the assignment of roles to legal bodies. This is likely to ensure the necessary coordination and oversight of security issues, thus ensuring that barriers of C-ITS uptake due to security concerns are reduced to a minimum. It is therefore likely that Policy Option 3 will have the greatest impact overall on deployment within the EU relative to the baseline.

Table 5-2 provides a summary of the impacts for each policy option relative to the baseline for impacts on security.

**Table 5-2. Summary of impacts on security for each policy option relative to the baseline**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security of C-ITS communications</td>
<td>The non-binding nature of the measures limits their effect on security.</td>
<td>Strong measures to reduce deployment barriers related to security by putting CP/SP policies into law, create a common trust domain. It is expected that this approach will have a significant impact on deployment, given the importance of security barriers.</td>
<td>The assignment of legal bodies is likely to ensure the necessary coordination and oversight of security issues, thus ensuring that barriers of C-ITS uptake due to security concerns are reduced to a minimum, leading to the greatest impact on uptake and deployment.</td>
</tr>
</tbody>
</table>

**Key:**

- **Significant positive impact**
- **Small positive impact**
- **Negligible/Neutral**
- **Small negative impact**
- **Significant negative impact**
5.1.3. Impacts on interoperability

As discussed in Section 2.3.6 lack of interoperable C-ITS services will hinder large-scale C-ITS deployment. Any intervention should aim to ensure that all vehicles are able to communicate with each other and infrastructure regardless of the communications technologies they use, and that backwards interoperability is ensured to the extent possible. To achieve these aims across the EU, guidance or specifications at the EU level are required. This was also highlighted in the Public Consultation where stakeholders of all types emphasised the need for EU level action, due to the cross-border nature of C-ITS. For example, a telecommunications provider noted that national action would not address cross-border needs sufficiently. One regional administration noted that C-ITS technology was global, so national action would be insufficient. As global action was unlikely, EU action was suggested to be the preferred option.

Policy Option 1 foresees a mandate to EU level standardisation organisations (ESOs) for standardisation of services beyond the Day 1 list. This measure is future looking and will help accelerate uptake of day 1.5 (and higher) services. It will speed up development of C-ITS on the industry side. The measure’s impacts on deployment are expected in the long term. Given that a lot of services beyond Day 1 (e.g. smart routing) have direct positive impacts on users (e.g. travel time savings) demand for C-ITS will increase.

In addition, Policy Option 1 requires the Commission to adopt non-binding guidelines to support the provisions as defined in the list of Day 1 services together with a reference to existing standards on interoperability and EU-wide service profiles. The introduction of such low-cost measures will have a limited effect but a positive impact on interoperability. Interoperability in turn will help access the benefits of C-ITS earlier. The more vehicles that are interoperable, the sooner network effects can be achieved; thus slight positive impacts on uptake are expected.

These measures were supported by stakeholders as there was consensus on the importance of common service profiles. The C-Roads platform representative emphasised the importance of referencing of technical standards, including basic requirements of backwards compatibility and interoperability. These measures allow the market to choose the best technologies to apply for C-ITS services by opening it to all users.

Assuming that the technical issues around standards for interoperability are addressed, Policy Option 2 should provide for a significant increase in impact from PO1. The requirement for all C-ITS stations to be compatible with all Day 1 services is a leap for interoperability. Further, it makes the stations more future proof. This is important for a robust C-ITS business case, since it makes scaling up more attractive from an investor’s point of view. The mandates for compliance with existing standards on interoperability and EU-wide service and system profiles of Day 1 services will ensure that all C-ITS services, where deployed, will be interoperable. This will help the EU access the benefits of C-ITS services more easily, resulting in stronger incentives for deployment. In addition, more certainty around the specifications for interoperability will ensure that C-ITS service providers will have a clearer view of the requirements that need to be met which will improve the clarity around suitable business models.

Regarding the question of whether these specifications should be mandated, stakeholders’ views were divided. While the C-Roads Flanders representative supported a mandate of specifications, other stakeholders highlighted the challenges of a mandate at this point in time (e.g. C-Roads Czech Republic). The NordicWay representative highlighted that the existing standards were not enough and that communication profiles are needed to ensure that all stakeholders apply the standards in the same way. InterCor UK mentioned that more knowledge on standards that are known to work for everyone is needed before they could support a mandate. The C-Roads Austria contact highlighted that the process for mandating technical standards was too slow to reflect new technologies that might require new standards. While the importance of mandates
of technical standards for improving interoperability has been acknowledged, challenges for an introduction in the short term have been highlighted.

The measures developed under Policy Option 2 reflect these concerns. By focusing on Day 1 services under Policy Option 2, it is ensured that only the technical specifications for the most mature services are being mandated. The suggestion that standards for services and communication profiles need to go hand in hand is addressed through measures under the policy options that cover both. Finally, the point on technical standards having to reflect new technologies is picked up by introducing a review clause that allows for an update of services and definitions when necessary.

**Policy Option 3** covers the same measures as Policy Option 2 and thus no additional direct impacts are expected. However, some indirect impacts are likely to arise from the measures on compliance assessment, which are stronger for Policy Option 3 than for Policy Option 2. Higher levels of compliance with interoperability requirements will have a positive impact on interoperability in general. The assignment of legal bodies will also help ensure the needed standards are met, whereas under PO2 these legal bodies may or may not end up being formed. In addition, the deployment mandate for vehicles (covered under continuity), which would be based on EU-wide standards, will provide another big push for interoperability.

In conclusion, Policy Option 1 would have some positive impact on interoperability but stakeholders considered this option with non-binding guidelines to be too weak to address the issues. Policy Options 2 and 3 on the other hand will result in significantly higher levels of interoperability due to the mandatory nature of the technical specifications.

Table 5-3 provides a summary of the impacts for each policy option relative to the baseline for the impacts on interoperability.

**Table 5-3. Summary of impacts on interoperability for each policy option relative to the baseline**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on interoperability</td>
<td>Positive impacts achieved will be more clarity on definition of services and reference to existing standards. The non-binding nature of the measures limits the impact on interoperability.</td>
<td>Significant positive impact expected on interoperability due to the binding nature of the measures.</td>
<td>Significant positive impact expected on interoperability due to the binding nature of the measures and mandatory deployment through the V2V mandate.</td>
</tr>
</tbody>
</table>
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Key:

<table>
<thead>
<tr>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant positive impact</td>
</tr>
<tr>
<td>Small positive impact</td>
</tr>
<tr>
<td>Negligible/Neutral</td>
</tr>
<tr>
<td>Small negative impact</td>
</tr>
<tr>
<td>Significant negative impact</td>
</tr>
</tbody>
</table>

5.1.4. Impacts on compliance

Compliance with the requirements set out under the different policy options is key to ensure their effectiveness. To ensure a seamless deployment of Day 1 C-ITS services, an effective compliance assessment framework is needed to allow C-ITS services and different types of C-ITS stations to be checked against EU-wide system requirements. As discussed in section 2.3.8 there are uncertainties with regards to the minimum requirements for compliance assessment for C-ITS services.

Stakeholders in the case study interviews also highlighted the need for a clear understanding of common minimum requirements for deployment of Day 1 C-ITS services. On the other hand, only 24 percent of respondents to the Public Consultation considered uncertainties around compliance as a very important driver contributing to the current overall problem faced by C-ITS, whereas interoperability, security and data privacy were deemed to be more important. Only deployment projects and technical experts might fully understand why compliance assessments are important, so public consultation responses should be seen in that context.

Policy Option 1 only includes non-binding guidelines on the compliance assessment process for Day 1 services as well as roles and responsibilities for the compliance assessment. As non-binding guidelines the measure will be low-cost but only of limited effectiveness.

Including a definition of compliance assessment criteria for Day 1 C-ITS services and an approval process for C-ITS stations in the specifications as suggested in Policy Option 2 is supported by stakeholders. Both are needed in combination as the C-Roads Austria contact highlighted. In combination these measures under Policy Option 2 are expected to have a significant impact on effectiveness as it will help ensure that where C-ITS is deployed, services are compliant. Compliance will enable all other measures to be effective and is thus indispensable for a functioning C-ITS system. The requirement for Member States to report on the bodies/authorities in charge for compliance assessment where set up will increase transparency and public knowledge. Knowledge sharing across countries will be facilitated through these bodies.

Assigning roles for compliance assessment to legal bodies in Member States as set out in Policy Option 3 will result in the highest impact with regards to coordination across Europe and compliance C-ITS requirements. Whereas in PO2 the bodies are not mandated, they are in this policy option. Assigning these roles however, will require a co-decision procedure and thus technical/legal feasibility might be critical.

Comparing the impacts of the three policy options regarding compliance assessment, Policy Option 1 is expected to only have a minor impact. Stakeholders consulted for the case studies showed support for the package of measures under Policy Option 2. Significant impacts on compliance are expected for this option. Additional impacts can be achieved through Policy Option 3 which covers assigning roles for compliance assessment to legal bodies as this ensures that compliance is assessed uniformly across Europe.
Table 5-4 provides a summary of the impacts for each policy option relative to the baseline for the impacts on compliance.

### Table 5-4. Summary of impacts on compliance for each policy option relative to the baseline

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on compliance</td>
<td>Small positive impact due to guidelines providing more clarity on the compliance assessment process and roles and responsibilities.</td>
<td>Positive impacts achieved through specifications around the approvals process, minimum criteria as well as needed roles in relation to the approvals process. Some limitations of effectiveness (with varying uptake across country groups) due to non-binding requirement to set up bodies/authorities in charge.</td>
<td>Strong positive impact (higher than PO2) through assigning roles for compliance assessment to legal bodies as this ensures that compliance is assessed uniformly across Europe.</td>
</tr>
</tbody>
</table>

**Key:**

- **Significant positive impact**
- **Small positive impact**
- **Negligible/Neutral**
- **Small negative impact**
- **Significant negative impact**

### 5.1.5. Impacts on continuity

Continuity of service, i.e. the availability of C-ITS services across the EU for end-users, is the most important factor for swift deployment of C-ITS in Europe. As stated in the European strategy on Cooperative Intelligent Transport Systems (European Commission, 2016) from the start, the services deployed should be as widely available as possible. Therefore, a coordinated deployment of C-ITS services by Member States and industry is of high priority.

In **Policy Option 1** continuity is supported through a stakeholder platform. The positive experience with the C-ITS platform (which ran until 2017) has been highlighted by stakeholders and a continuation of a similar platform is strongly supported. The C-Roads Czech Republic representative highlighted it could be useful to have a common library or knowledge sharing platform to bring together C-ITS information and make it accessible to a wider audience such as cities. Past experience with the platform has shown positive impacts. However this measure would do little to directly increase continuity of services.

**Policy Option 2** in addition foresees enhanced deployment coordination. Interviewed stakeholders support this measure, but the C-Roads Platform representative highlighted...
that this should be done through a central body. The NordicWay interviewee from Finland highlighted that such coordination might be straight-forward for Member State coordinated deployment but for commercial deployment this might be more challenging. Such increased coordination for C-ITS deployment will support interoperable implementation, ensuring that lessons learnt will be shared across projects. This will help follower countries access learning from more advanced countries and accelerate their uptake. Coordination of deployment will also help ensure that the most effective services are deployed in a similar manner. This is likely to have greater positive impacts than PO1 due to wider participation and involvement of Member States, including from follower countries.

Finally, **Policy Option 3** goes far beyond the other policy options by introducing mandatory deployment of V2V communication in new vehicles. This measure is significantly stronger as it mandates actual deployment. This policy option will significantly increase V2V service uptake across the whole of Europe. Stakeholders attending the stakeholder workshop on C-ITS in February 2018, however, highlighted that the overall impact of this mandate might be limited at first as most Day 1 services are V2I services and only few V2V services are covered in the Day 1 service list. However, the services that are covered are safety-related services, which received strongest support for a mandate from stakeholders in the public consultation. In addition, it is expected that high levels of uptake of V2V services will trigger enhanced V2I deployment.

This policy option is expected to be very effective in terms of ensuring continuity across Europe and also accelerating deployment of C-ITS. The responses received from stakeholders through the Public Consultation supported this, showing that the majority of stakeholders thought that a mandate in new vehicles should be introduced to accelerate deployment of C-ITS when services are fully functional and EU-wide specifications are in place. Stakeholders in support came from many stakeholder groups as shown in Figure 5-2.

**Figure 5-1: Public Consultation - Response on the level of agreement of statements in terms of accelerating deployment of C-ITS (when services are fully functional and EU-wide specifications are in place)**
Figure 5-2: Response on the level of agreement of statement 'C-ITS equipment should be mandated in new vehicles', by representing interest.
Table 5-5 provides a summary of the impacts for each policy option relative to the baseline for the impacts on continuity.

Table 5-5. Summary of impacts on continuity for each policy option relative to the baseline

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on continuity</td>
<td>Some positive impact expected through stakeholder platform, but little direct impact on continuity.</td>
<td>More positive impact on continuity compared to PO1 due to enhanced deployment coordination.</td>
<td>Significantly stronger measure than PO1 and PO2. Mandate on V2V services will be a very effective measure to ensure deployment of C-ITS services across Europe.</td>
</tr>
</tbody>
</table>

Key:

- Significant positive impact
- Small positive impact
- Negligible/Neutral
- Small negative impact
- Significant negative impact

5.1.6. Impacts on enabling conditions

Enabling conditions cover a range of measures that increase coordination across Europe and financial support for C-ITS.

Policy Option 1 focuses on funding for development of services beyond the Day 1 list. This measure is future-looking and will help accelerate uptake of day 1.5 (and higher) services. It will speed up development of C-ITS on the industry side and impact on deployment is expected in the long term. Given that a lot of services beyond Day 1 (e.g. smart routing) have direct positive impacts on users (e.g. reduction of travel time) demand for C-ITS will increase. In addition, Memoranda of Understanding with key stakeholders are envisaged. Support for this measure was shown by the C-Roads Platform representatives, who have previously been involved in MoUs with industry (VTS, 2017). Due to the non-binding nature of such an agreement, the impact of such a measure on deployment is limited, though it brings together the relevant stakeholders and encourages dialogue.

Policy Option 2 focuses on funding of deployment including requirements on data reporting and exchange for deployment projects to receive funding. Increased funding compared to PO1 will positively impact the level of deployment (depending on the specific change in the magnitude and nature of the funding). Data reporting and exchange requirements will ensure that lessons learnt will be shared across projects and help follower countries access learning from more advanced countries; thus accelerating their uptake.

Furthermore, this policy option covers EU deployment coordination beyond the current piloting phase. This is in line with a point made by the C-Roads Platform representative that funding should not only happen on a project by project basis but that there needs to be a funding programme that is fixed with a central body that coordinates newcomers to
C-ITS deployment and new technologies. Such measures would help ensure even geographic coverage of projects across all groups of countries, and not just front runner countries.

Policy Option 3 covers the same measures as Policy Option 2 and is not expected to result in further impacts on the enabling conditions.

In summary, Policy Option 1 covers a wide range of measures that help with progress in C-ITS R&D, agreements between stakeholders and consumer information. This is a good basis for improving the enabling conditions. Policy Options 2 and 3 go beyond that by providing deployment funding linked to data reporting and sharing requirements, which is expected to have a significant effect on learning and close the gaps in advancement between Member States through knowledge sharing. Furthermore, PO2 and PO3 cover EU-level coordination of deployment beyond the piloting phase, which is important for the future success of C-ITS deployment.

Table 5-6 provides a summary of the impacts for each policy option relative to the baseline for the impacts on enabling conditions.

Table 5-6. Summary of impacts on enabling conditions for each policy option relative to the baseline

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on enabling conditions</td>
<td>Positive impact on enabling conditions by providing funding for C-ITS development beyond Day 1 and bringing stakeholders together with MoUs.</td>
<td>Strong positive impact by providing funding for deployment projects linked to data reporting and sharing. This knowledge exchange will have a significant positive impact on learning and thus close gaps between Member States.</td>
<td>Same as PO2. EU deployment coordination beyond the piloting phase will further support this.</td>
</tr>
</tbody>
</table>

Key:

- Significant positive impact
- Small positive impact
- Negligible/Neutral
- Small negative impact
- Significant negative impact

5.2. Indirect impacts

While the policy options are focused on addressing the root causes to the problem of limited C-ITS deployment across the EU, they also have indirect impacts on:
- Road safety
- Reductions in urban travel time and other economic impacts
- Pollutant emissions and other environmental impacts

These impacts differ from policy option to policy option linked to the different uptake rates of C-ITS, discussed in section 4.7. These indirect impacts are estimated in the modelling framework as discussed in Annex B.

5.2.1. Impacts on road safety

Several C-ITS services (such as traffic jam ahead warning, hazardous location notification, in-vehicle speed limits, intersection safety etc.) specifically aim to improve road safety and to decrease both the number and severity of accidents. These impacts were modelled and monetised using external costs from the Handbook of External Costs (Ricardo-AEA, TRT, TEPR, DIW Econ, CAU, 2014). The external costs are in 2010 prices and are inflated to 2017 prices for the purposes of this report (and kept constant thereafter). However, all cumulative monetised impacts presented in this report are in present value terms, using a social discount rate of 4 percent to discount back to 2017.

Despite the large numbers of accidents avoided in the baseline scenario, significant further benefits are observed for all of the policy options. Figure 5-3 below shows the cumulative number of accidents avoided under each policy option relative to the baseline (one chart per policy option). Total accidents in these charts are further split by accident types – fatalities, serious injuries and minor injuries. In all policy options, accidents avoided are dominated by minor injuries. Policy Option 3 (PO3) is predicted to have the greatest impact on the number of accidents avoided relative to baseline by 2035. The detailed impacts (both in terms of accident numbers and external costs) are described by policy option in Table 5-8 and Table 5-9.
Figure 5-3: Cumulative number of accidents avoided by type relative to the baseline for the EU28
Table 5-7 below shows the absolute number of total accidents, in annual and cumulative terms under each scenario. For annual accidents in 2030 and 2035, the number of accidents decreases from the baseline to PO1, to PO2, then to PO3.

- Under PO1, the annual number of total accidents in 2030 represents 98.5 percent of the accidents in the baseline. For 2035, this figure is 96.8 percent.
- Under PO2, the annual number of total accidents in 2030 represents 94.6 percent of the baseline. For 2035, this is 89.6 percent.
- Under PO3, the annual number of total accidents in 2030 represents 91.5 percent of the baseline. For 2035, this is 88.1 percent.

Cumulative accidents between 2020-2030 and 2020-2035 show a similar trend. These are supplemented in the next two tables showing the difference from the baseline.

**Table 5-7: Total annual number of accidents and the cumulative number of accidents for the EU28 - 2030 / 2035**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Annual</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2030</td>
<td>2035</td>
</tr>
<tr>
<td>Baseline</td>
<td>1,348,000</td>
<td>1,294,000</td>
</tr>
<tr>
<td>PO1</td>
<td>1,328,000</td>
<td>1,253,000</td>
</tr>
<tr>
<td>PO2</td>
<td>1,275,000</td>
<td>1,160,000</td>
</tr>
<tr>
<td>PO3</td>
<td>1,233,000</td>
<td>1,141,000</td>
</tr>
</tbody>
</table>

Note: Figures have been rounded to the nearest 1,000.

Table 5-8 summarises the annual number and external cost of accidents, by accident type, under each scenario and relative to the baseline. There is a significant increase in external benefits and accident savings in all three policy options. Of the three policy options, PO3 is expected to deliver the greatest reduction in accidents, both in terms of

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34 Note that external costs for accidents are unique to each Member State, and thus the unit cost of accidents will vary depending on the composition of accidents in each Member State per policy option.
the number of accidents in 2030 and 2035 relative to the baseline and the present value of the external cost savings associated with those accidents. In 2030, PO3 is expected to save 114,000 accidents relative to the baseline. The accident cost saving associated with these avoided accidents for 2030 is €11,742 million. In 2035, the annual accidents avoided rises to 153,000 total accidents under PO3 – with an associated external cost saving of €15,596 million.

The largest grouping of accidents (minor injuries) is understandably predicted to see the greatest reductions compared to the baseline in all policy options. However, reductions in fatalities and serious injuries are anticipated to deliver the highest cost savings for all three policy options, due to being associated with much higher costs per accident. PO3 is predicted to save 2,000 fatalities in 2030 and 2,500 in 2035 compared to the baseline, with associated cost savings of €3,925 million and €4,868 million respectively for those years. For serious injuries, PO3 is expected to avoid 20,000 accidents in 2030 and 27,000 in 2035 - with associated cost savings of €5,736 million and €7,955 million respectively for those years.

**Table 5-8: Annual accidents and accident costs avoided relative to the baseline for the EU28 – by accident type, 2030 and 2035 for PO1, PO2 and PO3**

<table>
<thead>
<tr>
<th></th>
<th>2030</th>
<th>2035</th>
<th></th>
<th>2030</th>
<th>2035</th>
<th></th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annual</td>
<td>Annual</td>
<td>Annual</td>
<td>Annual</td>
<td>Annual</td>
<td>Annual</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>accidents</td>
<td>accident</td>
<td>accidents</td>
<td>avoided</td>
<td>avoided</td>
<td>avoided</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>avoided</td>
<td>cost</td>
<td>relative</td>
<td>relative</td>
<td>relative</td>
<td>relative</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>relative</td>
<td>to the</td>
<td>to the</td>
<td>to the</td>
<td>to the</td>
<td>to the</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>the baseline</td>
<td>baseline</td>
<td>baseline</td>
<td>baseline</td>
<td>baseline</td>
<td>baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatalities</td>
<td>300</td>
<td>€604 mn</td>
<td>600</td>
<td>€1,153 mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serious injuries</td>
<td>4,000</td>
<td>€1,071 mn</td>
<td>8,000</td>
<td>€2,267 mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor injuries</td>
<td>16,000</td>
<td>€358 mn</td>
<td>33,000</td>
<td>€730 mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20,000</strong></td>
<td><strong>€2,032 mn</strong></td>
<td><strong>41,000</strong></td>
<td><strong>€4,150 mn</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatalities</td>
<td>1,200</td>
<td>€2,393 mn</td>
<td>2,100</td>
<td>€4,119 mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serious injuries</td>
<td>13,000</td>
<td>€3,730 mn</td>
<td>24,000</td>
<td>€7,075 mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor injuries</td>
<td>59,000</td>
<td>€1,316 mn</td>
<td>107,000</td>
<td>€2,410 mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>72,000</strong></td>
<td><strong>€7,439 mn</strong></td>
<td><strong>134,000</strong></td>
<td><strong>€13,604 mn</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatalities</td>
<td>2,000</td>
<td>€3,925 mn</td>
<td>2,500</td>
<td>€4,868 mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serious injuries</td>
<td>20,000</td>
<td>€5,736 mn</td>
<td>27,000</td>
<td>€7,955 mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor injuries</td>
<td>93,000</td>
<td>€2,081 mn</td>
<td>124,000</td>
<td>€2,774 mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>114,000</strong></td>
<td><strong>€11,742 mn</strong></td>
<td><strong>153,000</strong></td>
<td><strong>€15,596 mn</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Accidents have been rounded to the nearest 1,000, save for fatalities, which is rounded to the nearest hundred.

Table 5-9 outlines the number of cumulative accidents avoided by type for each of the policy options for 2030 and 2035. The cumulative accident costs avoided (in present value terms) are also shown. All accident types (fatalities, serious injuries and minor injuries) are predicted to decrease under each of the policy options, though there are sizeable increases in benefits in moving progressively from PO1 to PO3. As with annual accidents, PO3 is anticipated to deliver the greatest reduction in each of the accident types in terms of the numbers of cumulative accidents and the respective external costs saved. Between 2020 and 2030, PO3 will see 533,000 total accidents avoided, with an external cost savings of €38 billion. Between 2020 and 2035, this policy option will see 1.2 million total accidents avoided, translating into €77 billion in external cost savings.
As with annual trends presented before, the largest grouping of accidents under minor injuries is predicted to see the greatest reductions compared to the baseline in all policy options. However, the costs avoided from fatalities and serious injuries make up the majority of the external cost savings for total accidents.

Table 5-9: Cumulative accidents and accident costs avoided relative to the baseline for the EU – by accident type, 2030 and 2035 for PO1, PO2 and PO3

<table>
<thead>
<tr>
<th>Accident Type</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cumulative accidents avoided relative to the baseline</td>
<td>Present value of accident cost avoided relative to the baseline</td>
</tr>
<tr>
<td>PO1 Fatalities</td>
<td>1,300</td>
<td>€2 bn</td>
</tr>
<tr>
<td>Serious injuries</td>
<td>15,000</td>
<td>€3 bn</td>
</tr>
<tr>
<td>Minor injuries</td>
<td>69,000</td>
<td>€1 bn</td>
</tr>
<tr>
<td>Total</td>
<td>85,000</td>
<td>€6 bn</td>
</tr>
<tr>
<td>PO2 Fatalities</td>
<td>5,500</td>
<td>€8 bn</td>
</tr>
<tr>
<td>Serious injuries</td>
<td>54,000</td>
<td>€11 bn</td>
</tr>
<tr>
<td>Minor injuries</td>
<td>260,000</td>
<td>€4 bn</td>
</tr>
<tr>
<td>Total</td>
<td>320,000</td>
<td>€23 bn</td>
</tr>
<tr>
<td>PO3 Fatalities</td>
<td>9,500</td>
<td>€13 bn</td>
</tr>
<tr>
<td>Serious injuries</td>
<td>88,000</td>
<td>€18 bn</td>
</tr>
<tr>
<td>Minor injuries</td>
<td>435,000</td>
<td>€7 bn</td>
</tr>
<tr>
<td>Total</td>
<td>533,000</td>
<td>€38 bn</td>
</tr>
</tbody>
</table>

Note: The number of fatalities have been rounded to the nearest 100, and all other accidents have been rounded to the nearest 1,000.
Table 5-10: Summary of impacts for each policy option relative to the baseline

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved road safety</td>
<td>PV 2020-2035 accident costs avoided, +1.0% compared to the baseline</td>
<td>PV 2020-2035 accident costs avoided, -3.5% compared to the baseline</td>
<td>PV 2020-2035 accident costs avoided, -5.0% compared to the baseline</td>
</tr>
</tbody>
</table>

Key:
- **Significant positive impact**
- **Small positive impact**
- **Negligible/Neutral**
- **Small negative impact**
- **Significant negative impact**

### 5.2.1.1. Impacts on vulnerable road users

As Section 5.2.1 revealed, all three policy options are likely to have a positive effect on the number of accidents avoided related to the baseline across all years, with PO3
anticipated to deliver the greatest impacts, although these modelled safety impacts do not include effects for vulnerable road users.

A considerable proportion of road accidents currently affect Vulnerable Road Users (VRUs); in 2015, 29 percent of all road deaths were attributable to pedestrians and cyclists (ETSC, 2016). Therefore, it can be assumed that an overall improvement in road safety may lead to a positive impact on the safety of VRUs.

Whilst a number of the Day 1 services being deployed in the policy options are aimed at improving safety generally, none of them are specifically aimed at the safety of pedestrians and cyclists. However, Day 1 C-ITS services will have an indirect impact on VRUs. Specific Day 1.5 services to protect VRUs will result in benefits if they are implemented\(^{35}\). The coordination mechanisms and funding for the development of services beyond day-1 included in PO2 and PO3 could support this.

Responses to the Public Consultation (PC) raised considerations relating to the potential impacts on VRUs. There were some concerns, for example from a consumers’ association and an association representing the bicycle industry, about the way in which vehicles with C-ITS would interact with other road users, particularly VRUs. There is currently no standard protocol for this, although some are being developed in specific projects. It was thought that more consideration of other modes (including VRUs) in the development of C-ITS could be of wider benefit and better help cities to deliver modal shift. It was suggested that the involvement of VRUs in the development of C-ITS would be useful.

PC respondents also raised concerns that C-ITS could be a distraction to drivers, subsequently leading to potential adverse impacts on VRUs. It was proposed that the European Statement of Principles on Human Machine Interface (European Commission, 2008) should be updated to take account of C-ITS. Driver training and education in relation to C-ITS was considered to be important by one stakeholder and that this should be mandated as part of the qualifications of professional drivers. It was noted that the needs of those with disabilities should be remembered in the development of C-ITS. It was also noted that motorcyclists had different needs compared to other road users, which should also be recognised.

A briefing by the European Transport Safety Council (ETSC, 2016) considers the implications of automated driving on safety, including VRUs. Particular concerns were raised relating to the introduction and transitional stages of automated driving in relation to risk to VRUs. Whilst it is acknowledged that some of the in-vehicle safety technologies that are already being deployed are specifically able to help prevent collisions with VRUs, cyclists and pedestrians are currently largely unequipped with ITS safety equipment which may allow them to interact with automated vehicles. Whereas in this study we model the deployment of C-ITS via smartphones (personal C-ITS devices), we assume that phones would not be able to undertake Bundle 1 safety services that are time critical, given the latency constraints of 3G/4G communication. However, the technology could develop in the future to allow this, which would have positive benefits for VRUs.

PC respondents recognised that in the longer-term, C-ITS that enables interaction between all vehicles – including bicycles – was foreseen to have potential significant benefits for road safety, including for VRUs. The case studies demonstrated that this was starting to happen, including in the US, where a range of products are being developed, which could include a notice of pedestrians crossing roads; such services would potentially be of benefit to VRUs. Japan is also targeting a range of applications, including ‘pedestrian existence advisory systems’ and ‘crossing pedestrian recognition enhancement systems’ (see Annex D for further information on the case studies).

The European Transport Safety Council’s report on C-ITS (ETSC, 2017) identifies studies that have been undertaken with recommendations on how VRUs can be integrated in

\(^{35}\) Day 1.5 services are not included in the policy options but are included in results for the deployment scenarios.
order to reap the full benefits of C-ITS, including their use on bicycles. Research is also required to assess the risk amongst the VRUs of C-ITS. In order to reduce the risk of C-ITS distracting drivers and so adversely affecting the safety of VRUs, it will be important to ensure the appropriate design of the interface between C-ITS and drivers in order to reduce the risk of C-ITS distracting drivers and subsequently affecting the safety of vulnerable road users. Potential ways of achieving this may be by updating the European Statement of Principles on Human Machine Interface (European Commission, 2008) to take account of C-ITS (as proposed by one stakeholder) and ensure that drivers are trained and educated appropriately.

Table 5-11 provides a summary of the impacts for each policy option relative to the baseline for the impacts on vulnerable road users.

**Table 5-11. Summary of impacts on vulnerable road users for each policy option relative to the baseline**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on vulnerable road users</td>
<td>No VRU specific C-ITS services. Limited impacts achieved.</td>
<td>PO1 + coordination mechanisms and funding for the development of services beyond day-1 help implementation of VRU C-ITS services.</td>
<td>PO1 + coordination mechanisms and funding for the development of services beyond day-1 help implementation of VRU C-ITS services.</td>
</tr>
</tbody>
</table>

**Key:**
- **Significant positive impact**
- **Small positive impact**
- **Negligible/Neutral**
- **Small negative impact**
- **Significant negative impact**

**5.2.2. Economic impacts**

In this section, we cover impacts on investment and operating costs, the financial burden for private sector/public authorities and distributional impacts, urban travel time impacts, macroeconomic impacts and impacts on SMEs.

**5.2.2.1. Impacts on investment and operating costs**

In the deployment of C-ITS technologies, an important cost factor consists of C-ITS equipment for new vehicles, personal C-ITS devices, roadside infrastructure upgrades, new roadside infrastructure, and central sub-systems. Figure 5-4 below shows the present value of these additional cumulative costs from 2019 to 2035 in each policy option relative to the baseline. The assumptions and inputs on costs are described in detail in Annex B, section B.2.4. Not unexpectedly, PO3 has the steepest increase in equipment costs compared to the baseline, reaching €32 billion by 2035 (€21 billion by 2030) in present value terms. This is due to the V2V vehicle mandate. There is also a significant uplift in deployment under PO2 and so total cumulative equipment costs reach €19 billion by 2035 (€11 billion by 2030). The costs associated with PO1 are the lowest.
The present value of cumulative total equipment costs for 2020-2030 and 2020-2035 are also displayed in Table 5-12 below, along with the additional costs relative to the baseline. PO3 additional costs relative to the baseline by 2030 are nearly double those under PO2. On the other hand, these costs increase more than three-fold by 2030 between PO1 and PO2. Similar trends are evident for cumulative total equipment costs between 2020-2035.

### Table 5-12: Present value of equipment costs relative to the baseline for EU28 – 2030 / 2035

<table>
<thead>
<tr>
<th>Scenario</th>
<th>PV 2020-2030</th>
<th>Additional PV costs relative to the baseline in 2030</th>
<th>PV 2020-2035</th>
<th>Additional PV costs relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>€9.6 bn</td>
<td>-</td>
<td>€17.7 bn</td>
<td>-</td>
</tr>
<tr>
<td>PO1</td>
<td>€12.5 bn</td>
<td>€2.8 bn</td>
<td>€22.6 bn</td>
<td>€4.9 bn</td>
</tr>
<tr>
<td>PO2</td>
<td>€20.9 bn</td>
<td>€11.3 bn</td>
<td>€36.8 bn</td>
<td>€19.1 bn</td>
</tr>
<tr>
<td>PO3</td>
<td>€30.7 bn</td>
<td>€21.1 bn</td>
<td>€50.0 bn</td>
<td>€32.3 bn</td>
</tr>
</tbody>
</table>

Figure 5-5 shows a breakdown of the annual equipment costs each year (in present value terms) under each policy option relative to the baseline. Each chart’s background marks which policy option it refers to. In all three policy options, new vehicles dominate costs, followed by personal C-ITS devices. Annual total equipment costs generally increase year on year for PO1 and PO2, but in PO3 they peak in 2028, which is the point at which 100 percent of new vehicles in the fleet have been equipped.

---

36 While there is no smartphone purchase cost factored into the costs for personal C-ITS devices, there are costs per device for security and extra data usage. Finally, EU-wide, there are costs for app development for C-ITS apps.
Figure 5-5: Total annual equipment costs: Composition of policy option costs relative to baseline for EU 28
While public authorities incur costs for installing infrastructure and central ITS sub-systems, this equipment can help them enhance their overall administration and management of road systems. For example, data from vehicles can help cities identify congestion hotspots more easily, or roads where driving speeds are reduced due to maintenance required.

We have not modelled the administrative burden for deployment projects and Member States of complying with the proposed policy options. Under PO1, compliance is voluntary, and compliance costs will depend on uptake of C-ITS by deployment projects. Any costs for complying with the guidelines issued would fall to deployment projects. For example, where uptake is positive, they would incur costs to adhere to the GDPR guidance, the Certificate & Security Policy, compliance assessment recommendations, and any coordination costs through the stakeholder platform. Where deployment projects are receiving support from Member States, Member States may also incur compliance costs. If the administrative burden were high for any aspect in adhering to recommended guidelines, projects and Member States could simply decide to apply other standards to deploy C-ITS projects. In this sense, the administrative burdens are not significant under PO1.

Under PO2, compliance is mandatory and deployment projects/Member States will need to comply with a number of rules:

- GDPR specifications adopted for C-ITS: Relative to PO1, however, compliance with GDPR should now be easier (and hence less costly) for all parties involved as more clarity is provided.
- Certificate and Security Policy: There will be some compliance costs for deployment projects and any central ITS sub-systems managed by MS.
- Interoperability: There may be some costs involved in ensuring stations can support all Day 1 services if they would not otherwise have planned to, but they are not likely to be significant as most services are based on similar standardised messages.
• Compliance assessment: There would be costs involved in the approval process for deployment projects getting a C-ITS station approved and adhering to any compliance assessments.

• Continuity: There may be some small additional costs in attending more stakeholder meetings and workshops under this measure. This would apply to deployment projects as well as MS. However, these would be minor and funded under the following measure.

• Enabling conditions: This would be a net benefit for deployment projects and MS, rather than a cost, as it would provide more funding for deployment.

Thus under PO2, the key compliance costs would be adherence to the Certificate and Security Policy for deployment projects and MS and compliance assessment activity for deployment projects. Such costs are likely to be very low relative to the costs of equipment incurred for infrastructure by Member States and deployment projects. Compared to the cost sensitivity calculated earlier, any increases in compliance costs here would have very limited impact, if any.

Under PO3, many of the measures are the same as PO2, but some change that may imply extra costs compared to PO2:

• Security bodies: Any such bodies set up are likely to be EU-wide bodies in order to maximise interoperability between MS. Thus, no specific costs to MS or deployment projects are incurred here.

• Compliance assessment bodies: Any such bodies set up are likely to be EU-wide bodies in order to maximise interoperability between MS. Thus, no specific costs to MS or deployment projects are incurred here.

• Continuity: Equipment costs from a V2V deployment mandate are incurred by OEMs. Any administrative costs for monitoring that OEMs comply are likely to be incurred at the EU, not MS level, as OEMs work across borders.

Thus, PO3 does not incur excess administrative costs for deployment projects or MS above and beyond those of PO2.

5.2.2.2.  Financial burden for the private sector, public authorities and distributional impacts

In Figure 5-5, we showed a decomposition of equipment costs by category: new vehicles, personal C-ITS devices, infrastructure upgrades, new infrastructure, and central ITS sub-systems. While we do not explicitly model the public/private split in terms of equipment costs incurred, we can roughly infer such a split from assigning categories of equipment costs to each group. If we assign infrastructure costs to the public sector and vehicle/personal C-ITS device costs to the private sector, by 2030 and 2035 most costs are assigned to the private sector. In turn, the private sector could pass these costs on to consumers and so in our model, all in-vehicle and personal C-ITS device costs are end-user costs, not producer costs. The below tables show this split for PO1, PO2, and PO3. What is evident is that the private sector burden increases as one moves from PO1-PO3. This is consistent with the main costs (new vehicle equipment and personal C-ITS device cost) being incurred by the private sector, so as deployment increases successively through each policy option, the private sector burden increases.

Table 5-13: Present value of equipment costs by sector in PO1 for EU28 – 2030 / 2035

<table>
<thead>
<tr>
<th>Category</th>
<th>PV 2020-2030</th>
<th>PV 2020-2035</th>
<th>% of total cost 2030</th>
<th>% of total cost 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public equipment costs</td>
<td>€0.7 bn</td>
<td>€1.1 bn</td>
<td>24.2%</td>
<td>23.1%</td>
</tr>
<tr>
<td>Private equipment costs</td>
<td>€2.2 bn</td>
<td>€3.8 bn</td>
<td>75.8%</td>
<td>76.9%</td>
</tr>
</tbody>
</table>
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Table 5-14: Present value of equipment costs by sector in PO2 for EU28 – 2030 / 2035

<table>
<thead>
<tr>
<th>Category</th>
<th>PV 2020-2030</th>
<th>PV 2020-2035</th>
<th>% of total cost 2030</th>
<th>% of total cost 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public equipment costs</td>
<td>€1.6 bn</td>
<td>€2.5 bn</td>
<td>14.1%</td>
<td>13.2%</td>
</tr>
<tr>
<td>Private equipment costs</td>
<td>€9.7 bn</td>
<td>€16.6 bn</td>
<td>85.9%</td>
<td>86.8%</td>
</tr>
</tbody>
</table>

Table 5-15: Present value of equipment costs by sector in PO3 for EU28 – 2030 / 2035

<table>
<thead>
<tr>
<th>Category</th>
<th>PV 2020-2030</th>
<th>PV 2020-2035</th>
<th>% of total cost 2030</th>
<th>% of total cost 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public equipment costs</td>
<td>€1.8 bn</td>
<td>€2.9 bn</td>
<td>8.7%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Private equipment costs</td>
<td>€19.2 bn</td>
<td>€29.5 bn</td>
<td>91.3%</td>
<td>91.2%</td>
</tr>
</tbody>
</table>

5.2.2.3. Impacts on fuel consumption and associated cost savings

Services aimed at smoothing out uneven traffic flow and at reducing urban travel time (e.g. hazardous location notification and traffic signal priority) will lead to a reduction in fuel consumption. As displayed in Figure 5-6, each policy option results in a reduction in fuel consumption relative to the baseline. Policy Option 3 has the most significant impact, followed closely by Policy Option 2. Policy Option 1 generates the smallest fuel consumption savings relative to the baseline.

Figure 5-6. Total annual fuel consumption savings relative to the baseline

When the monetary savings associated with a reduction in fuel consumption are considered, Table 5-16 shows that there are significant economic benefits. In PO3, the present value of savings relative to the baseline between 2020-2030 is €9.2 billion and €18.2 billion between 2020-2035. These savings for PO1 and PO2 between 2020-2035 are €2.5 billion and €11.2 billion respectively. The fuel price is calculated as a weighted average of prices of gasoline, diesel, CNG, LPG and electricity, based on energy consumption of road transport modes, excluding tax and VAT.
Table 5-16. Present value fuel costs and savings relative to the baseline for EU28 – 2030 / 2035

<table>
<thead>
<tr>
<th>Scenario</th>
<th>PV 2020-2030</th>
<th>Saving relative to the baseline in 2030</th>
<th>PV 2020-2035</th>
<th>Saving relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>€1,961 bn</td>
<td>-</td>
<td>€2,652 bn</td>
<td>-</td>
</tr>
<tr>
<td>PO1</td>
<td>€1,962 bn</td>
<td>€1.1 bn</td>
<td>€2,654 bn</td>
<td>€2.5 bn</td>
</tr>
<tr>
<td>PO2</td>
<td>€1,966 bn</td>
<td>€4.9 bn</td>
<td>€2,663 bn</td>
<td>€11.2 bn</td>
</tr>
<tr>
<td>PO3</td>
<td>€1,970 bn</td>
<td>€9.2 bn</td>
<td>€2,670 bn</td>
<td>€18.2 bn</td>
</tr>
</tbody>
</table>

In addition to equipment costs incurred by the public sector, future tax revenues will change. Future fuel duty revenues are expected to vary by policy option due to variable uptake of C-ITS under each policy option and thus variable future fuel consumption (discussed above). Table 5-17 shows the decrease relative to the baseline for 2030 and 2035, with the greatest decrease for Policy Option 3 at 1.19 and 1.41 percent lower than baseline fuel duty revenues. These are minor shifts from the baseline values.

Table 5-17: Annual fuel duty revenue changes by policy option relative to the baseline for the EU28 – 2030 / 2035

<table>
<thead>
<tr>
<th>Grouping</th>
<th>PO1 2030</th>
<th>PO2 2030</th>
<th>PO3 2030</th>
<th>PO3 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU 28</td>
<td>-0.15%</td>
<td>-0.26%</td>
<td>-0.66%</td>
<td>-1.13%</td>
</tr>
</tbody>
</table>

Another output of the ASTRA model is modal split, which is estimated from the changes in travel time and cost, and computed using passenger km. There is no significant change in the modal split compared to the baseline. Overall, the modal split is dominated by personal vehicles, which account for 69 percent of transport.
5.2.2.4. **Impacts on urban travel time**

As outlined in Table 1-1, the C-ITS services in the Day 1 priority list that reduce urban travel time are:

- Hazardous location notification (HLN)
- Traffic signal priority request by designated vehicles (TSP)

Benefits in terms of the reduction in urban travel time were calculated for cars and buses. The time cars and buses spent driving in urban areas (an output from TRT’s ASTRA model) was multiplied by the cost of time of €8.80 (from the Handbook of External Costs - assuming 50 percent commuting trips and 50 percent other trips) to calculate the cost of time spent travelling. The baseline value was then subtracted from the policy scenario, to produce the cost/benefit of the increase/reduction in time spent travelling in urban areas.37

The impact of reduced travel time is shown in Figure 5-7. Under PO1, travel time savings are the lowest - €753 million in 2035 (€220 million in 2030). These increase in PO2, with savings of €4.4 billion in 2035 (€1.1 billion in 2030). The greatest savings are in PO3. In 2035, our models predict savings of up to €10.1 billion in PO3 (€3.5 billion in 2030).

**Figure 5-7: Total additional annual value of time savings relative to baseline for the EU28**

Table 5-18 shows the cumulative (monetary) impacts of these time savings by policy option in present value terms. The greatest impacts are in Policy Option 3, reaching €7.7 billion and €28.2 billion in 2030 and 2035, respectively. PO2 achieves significant impacts and PO1 creates moderate impacts.

37 Average occupancy factors were also taken into consideration for both cars (1.7) and buses (19 people).
Table 5-18: PV total urban travel time savings relative to the baseline for the EU28 – 2030 / 2035

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO1</td>
<td>€0.5 bn</td>
<td>€2.0 bn</td>
</tr>
<tr>
<td>PO2</td>
<td>€2.5 bn</td>
<td>€10.8 bn</td>
</tr>
<tr>
<td>PO3</td>
<td>€7.7 bn</td>
<td>€28.2 bn</td>
</tr>
</tbody>
</table>

The impact of travel time savings in hours is shown in Figure 5-8. As expected it follows the same trend as Figure 5-7, with Policy Option 3 resulting in the greatest time savings and PO1 the least. The total annual savings in urban travel time are driven by buses, while negative time savings are observed for cars. The baseline trend for both cars and buses is an increase in urban travel time. Hazard Location Notification service contributes to an increase in average speed for both cars and buses but in Vehicle Speed Limits results in a reduction in average speed for cars, while Traffic Signal Priority provides a significant increase in average speed for buses. These impacts drive the modelled trends shown for the policy options. Day 1.5 services, however, such as Parking Information, are expected to bring significant additional travel time savings for cars in urban areas.

**Figure 5-8. Total annual time savings relative to baseline for the EU28**

For the EU28, the model predicts the following annual urban travel time savings relative to the baseline:

- Under PO1, annual savings relative to the baseline for the EU28 represent 0.04 percent of the baseline in 2030, and 0.12 percent in 2035.
- Under PO2, annual savings relative to the baseline for the EU28 represent 0.20 percent of the baseline in 2030, and 0.70 percent in 2035.
Under PO3, annual savings relative to the baseline for the EU28 represent 0.57 percent of the baseline in 2030, and 1.61 percent in 2035. However, there are greater impacts on travel time in Day 1.5 services, and the travel time savings shown in Annex C: Deployment Scenarios are enhanced strongly by the addition of these services.

**Urban travel time Member State examples**

Under PO1, the Netherlands (a Front Runner) has the lowest travel time benefits. Across PO2 and PO3, benefits for the Netherlands increases, and the saving relative to the baseline is higher than for Poland in 2035 in PO3, although not as high as for the Czech Republic. The Czech Republic has the largest proportion of urban travel time assigned to buses compared to cars, resulting in it having the greatest savings relative to the baseline.

**Annual per capita urban travel time savings relative to the baseline for NL, CZ, PO and the EU28 – 2030 / 2035**

<table>
<thead>
<tr>
<th>Country</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saving relative to the baseline in 2030</td>
<td>Saving relative to the baseline in 2035</td>
<td>Saving relative to the baseline in 2030</td>
<td>Saving relative to the baseline in 2035</td>
</tr>
<tr>
<td>NL</td>
<td>-€ 0.3</td>
<td>-€ 0.1</td>
<td>-€ 0.1</td>
</tr>
<tr>
<td>CZ</td>
<td>€ 1.8</td>
<td>€ 5.3</td>
<td>€ 6.0</td>
</tr>
<tr>
<td>PL</td>
<td>€ 0.8</td>
<td>€ 2.2</td>
<td>€ 2.7</td>
</tr>
<tr>
<td>EU28</td>
<td>€ 0.4</td>
<td>€ 1.5</td>
<td>€ 2.1</td>
</tr>
</tbody>
</table>

**5.2.2.5. Macroeconomic impacts**

**GDP impacts**

Table 5-19 shows GDP impacts of the three policy options for the EU28, an output of the ASTRA model. Overall annual GDP impacts are not significant under PO1. They are also very limited in PO2 and PO3.

**Table 5-19: Annual GDP impacts by policy option relative to the baseline – 2030 / 2035**

<table>
<thead>
<tr>
<th>Grouping</th>
<th>PO1 2030</th>
<th>PO1 2035</th>
<th>PO2 2030</th>
<th>PO2 2035</th>
<th>PO3 2030</th>
<th>PO3 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU28</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.01%</td>
<td>0.02%</td>
<td>0.02%</td>
<td>0.03%</td>
</tr>
</tbody>
</table>

**Impacts on job creation and new business opportunities**

Another macroeconomic impact is new job creation related to the manufacturing, installation, maintenance and operation of new C-ITS technologies. Part of the driver behind job creation will be a more efficient use of information as a result of widespread C-ITS deployment. This increase, however, may be offset by job losses in other areas,
such as jobs involved in the value chain related to superseded technologies or service jobs lost as a result of C-ITS technologies.  

The impact on job creation is estimated using multipliers, since the use of general equilibrium models is not in the scope of this study. These should be interpreted with caution due to the inability of such simple models to take into account whole economy displacement effects (inclusive of jobs lost in other areas). Despite this, overall employment estimates should give a guide on the potential magnitude of employment impacts.

We used direct employment multipliers covering the manufacture of motor vehicles, electrical equipment, and other transport equipment industries to translate the total net economic impact of each policy option. The indirect employment multipliers used cover the electrical and transport equipment industries.

The impact on total EU employment in 2030 and 2035 has been estimated to be between 13,350 and 85,370 additional jobs for the three policy options, taking into account employment effects for relevant industries based on the additional costs of deploying C-ITS services for each policy option relative to the baseline. These are shown for each policy option and type of employment impact in Table 5-20.

**Table 5-20: Employment impacts by policy option relative to the baseline for the EU28 – 2030 / 2035**

<table>
<thead>
<tr>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2030</td>
<td>2035</td>
<td>2030</td>
</tr>
<tr>
<td>Total EU employment in 2016</td>
<td>214,235,000</td>
<td></td>
</tr>
<tr>
<td>Total EU information &amp; communications employment (2016)</td>
<td>6,537,228</td>
<td></td>
</tr>
<tr>
<td>Direct additional jobs</td>
<td>4,420</td>
<td>5,910</td>
</tr>
<tr>
<td>Indirect additional jobs</td>
<td>8,930</td>
<td>11,940</td>
</tr>
<tr>
<td>Total jobs</td>
<td>13,350</td>
<td>17,850</td>
</tr>
<tr>
<td>% EU Employment (from total jobs)</td>
<td>0.002%</td>
<td>0.003%</td>
</tr>
<tr>
<td>% of EU information &amp; communications employment (from total jobs)</td>
<td>0.14%</td>
<td>0.18%</td>
</tr>
</tbody>
</table>

The estimation of direct job-related impacts follows:

- Taking the additional annual cost of deploying C-ITS services in 2030 and 2035 relative to the baseline for each policy option
- Multiplying this by the average employment effect for an average of the relevant industries (estimated to be 9.03 FTE change per €1.2mn of output)

The number of indirect jobs created is estimated via the use of employment multipliers. Assuming an average Type I employment multiplier of 1.89 for the electrical and

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38 This is why employment multipliers are not an exact measure of potential job creation, as they usually do not take into account jobs that disappear.

39 All jobs have been rounded to the nearest 10, so numbers may not sum exactly. No baseline has been modelled as part of this project for 2030 and 2035.
transport equipment sectors, further indirect jobs (under each policy option) are created due to the deployment of C-ITS services in 2030 and 2035, respectively. Direct and indirect jobs sum up to indicate total potential jobs due to the increased expenditure on C-ITS in each of the policy options. The total direct and indirect jobs created represent between 0.002 - 0.013 percent of total EU employment, or 0.14-0.95 percent of information and communication employment under each policy option.

Stakeholder responses in the Public Consultation (PC) were positive on the potential employment impacts of C-ITS. When asked about the impact of the likely new services that will come into the market due to C-ITS and create new jobs, nearly all respondents agreed with the statement that new jobs would be created as a result. Only 4 percent disagreed. Another stakeholder, 5GAA, submitted a report that also estimated the job creation potential of different ways forward as part of the PC.

Overall, respondents to the PC suggested that as C-ITS would allow information to be used more efficiently, it would lead to more jobs being created. Those directly involved in the supply of the relevant hardware, or in the development of relevant services, noted that they anticipated increased sales and jobs as a result of an increase in C-ITS. In the longer-term, as the transition to CCAM progresses, it could improve the access to jobs of those with mobility impairments.

(c) Research & Innovation (R&I) impacts

In this subsection we provide a high-level qualitative assessment of the impacts of the policy options on R&I in the EU from the available literature and stakeholder feedback. These types of impacts help improve the competitiveness of EU industry by encouraging innovation, improving productivity, and helping companies grow.

A recent study for JRC found that the sharing of electronic data by firms has a positive relationship with product innovation observed, in particular for manufacturing firms. The percentage of firms who shared electronic data was positively related to turnover due to new products, and the overall share of firms displaying product and process innovations. Specifically, the study found that:

- A 10 percent increase in the number of firms sharing electronic data was associated with a 0.8 percent increase in manufacturing firms’ turnover due to new market products (Falk, 2015, p. 39).
- A 10 percent increase in the number of firms sharing electronic data was associated with a 5.6 percent increase in the share of manufacturing firms with product innovations (Falk, 2015, p. 39).
- A 10 percent increase in the number of firms sharing electronic data was associated with a 5.1 percent increase in the share of manufacturing firms with process innovations (Falk, 2015, p. 40).

As C-ITS deployment means an increase in firms sharing electronic data, it is expected that companies participating in the market would benefit from such effects. In addition, a 2010 study for the European Commission on the impact of ICT on the economy showed that ICT improvements are associated with higher firm productivity and expansion. The study found that:

- A 10 percent increase in ICT capital is associated with a 0.23 percent increase in firm productivity (Bloom, et al., 2010, p. 6).
- Firms in the top two quintiles for ICT intensity expand about 25-30 percent faster (Bloom, et al., 2010, p. 7).

40 See Figure 2-28 in the Public Consultation Report.

41 The effect was not significant for service firms.
Since C-ITS equipment and use will increase overall ICT use for the transport sector, we anticipate that companies operating in the sector will reap similar benefits.

In responses to the Commission’s Public Consultation, most stakeholders (106 out of 135) agreed with the Commission’s suggestion that the deployment of C-ITS will have a positive impact on research and innovation.\(^{42}\) In addition, a number of stakeholders wrote that a binding legal framework would promote innovation, although it was also noted that if the legal framework was too rigid it risked preventing innovation.

Many of the case studies described in Annex D contain a lot of research and innovation, as the aim is to demonstrate early deployment of C-ITS. Research from our case studies suggested that the new information made available by C-ITS could lead to innovation as companies identify new ways of using these data. In addition to increasing innovation, R&I could also be better aligned to meet societal needs. For example, one of the strategic themes of the US ITS Strategic Research Plan is to promote innovation by aligning transport needs with research and development.

Clarifying the regulatory framework around C-ITS would reduce the risk around the development of C-ITS. This should encourage more companies to research new ways of using the data generated and new products and services. It would also be a first step towards CCAM, which will potentially revolutionise the way we travel, providing the first step to a long-term innovative transformation.

### 5.2.2.6. Impacts on SMEs

In this section we provide a high-level analysis of the likely role that SMEs will play in the deployment of C-ITS under the policy options.

On the supply side it is envisaged that SMEs will have a role to play in the development, installation and maintenance of the technologies that support C-ITS deployment. In fact, for data services stemming from technologies such as C-ITS, a recent report suggests the majority of data companies are SMEs. This research measured the proportion of SMEs in the data economy, finding that 98.9 percent of data companies were SMEs and 99.5 percent of potential data companies were SMEs (IDC, 2017, p. 83). Thus, we expect that many of the data companies who will be involved in C-ITS services may be SMEs. Many road haulage companies are also SMEs, so SMEs may also benefit from time efficiencies delivered by C-ITS services in the haulage sector, increasing their competitiveness. On the other hand, SMEs may experience delayed access to C-ITS services, since SMEs typically have smaller resources compared to larger companies (and typically purchase second-hand commercial vehicles rather than new).

In submissions to the Commission’s Public Consultation, a number of stakeholders considered that standardisation and ‘legally-enforced transparency’ were important to enable SMEs to access the C-ITS market, although it was suggested that the participation of SMEs was dependent on there not being a significant increase in administrative burden as a result of any standards or protocols. One stakeholder referred to a study that had suggested that SMEs were expected to play a role in the installation and operation of C-ITS; while others disagreed, concerned that larger companies would dominate the market. Stakeholders suggested that the potential role of SMEs was linked to the room for innovation, with the implication that the more room there was for innovation, the higher the potential involvement of SMEs. Overall, some degree of standardisation and transparency would seem to be more likely to help SMEs, although if this reduced the potential for innovation, then this might limit the potential engagement of SMEs.

Our case studies in Annex D also illustrate some of the potential impacts on SMEs from these projects. Our interview with C-ROADS Austria suggested that new information made available by C-ITS could lead to start-ups using this information in innovative

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\(^{42}\) See Figure 2-28 in the Public Consultation report.
ways. As SMEs are often more flexible than larger companies and so more able to take advantage of new ideas, this is likely to be done by SMEs. On a related note, an interview with the C-ROADS platform suggested that road operators are already buying resources and knowledge from SMEs, which may lead to their later acquisition. This is likely to stem from the fact that SMEs, as early innovators in new areas, may then be acquired by larger companies.

The NordicWay project has demonstrated potentially positive impacts on SMEs. An SME has been involved in the project, providing specific expertise. Further C-ITS deployment may influence SMEs in similar areas of the system. SMEs have also been involved in C-ROADS France – they’ve gained valuable knowledge, which has enabled them to scale up manufacturing. This is also the case for C-ROADS Germany – the potential for greater opportunities for SMEs is a result of having access to open data, which will lower the cost of developing services based on this information.

In terms of any direct impacts, theoretically it could be considered to include a derogation for SMEs from parts of the binding specifications (PO 2&3) or the mandatory deployment of V2V technology (PO3); however, a derogation from parts of the binding specifications would not be advisable as this would negatively affect the safety, security, and interoperability across the EU.

Although SMEs may find that some regulations prove to be barriers, the enhanced deployment of C-ITS allowed by these regulations may also give them greater roles for providing innovative products and services to the market. In this sense, Policy Option 3 is likely to have the greatest impact due to higher deployment, but Policy Option 2 may also give companies in the market much needed regulatory certainty to enable them to make efficient investments in new products and services.

5.2.2.7. Summary and conclusions

Table 5-21 provides a summary of each of the economic impacts described for each policy option relative to the baseline, colour-coded according to expected impact.

Table 5-21: Summary of impacts for each policy option relative to the baseline

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV equipment costs 2020-2035</td>
<td>Increased expenditure relative to baseline (27.7%)</td>
<td>Increased expenditure relative to baseline (108.0%)</td>
<td>Increased expenditure relative to baseline (182.8%)</td>
</tr>
<tr>
<td>Administrative burdens for MS and deployment projects</td>
<td>Compliance optional. If administrative burdens too high, Member States and projects would choose not to comply and avoid incurring high costs.</td>
<td>Key compliance costs are adherence to the Certificate and Security Policy and compliance assessment. Costs likely to be very low relative to the equipment costs for infrastructure.</td>
<td>No excess costs beyond those incurred in PO2.</td>
</tr>
<tr>
<td>Public/Private sector split in PV 2020-2035 equipment costs</td>
<td>Most expenditure by private sector (76.9% spend by private sector)</td>
<td>Most expenditure by private sector (86.8% spend by private sector)</td>
<td>Most expenditure by private sector (91.2% spend by private sector)</td>
</tr>
<tr>
<td>Fuel consumption costs</td>
<td>PV 2020-2035 fuel consumption costs reduced, -0.1% compared to the baseline</td>
<td>PV 2020-2035 fuel consumption costs reduced, -0.4% compared to the baseline</td>
<td>PV 2020-2035 fuel consumption costs reduced, -0.7% compared to the baseline</td>
</tr>
<tr>
<td>Annual fuel duty revenue changes by 2035</td>
<td>Less revenue for public sector relative to baseline (-0.26%)</td>
<td>Less revenue for public sector relative to baseline (-1.13%)</td>
<td>Less revenue for public sector relative to baseline (-1.41%)</td>
</tr>
<tr>
<td>Modal Split</td>
<td>No significant impact</td>
<td>No significant impact</td>
<td>No significant impact</td>
</tr>
</tbody>
</table>
The following section presents the modelled environmental impacts of the three policy options. The environmental impacts considered include:

- Changes in CO₂ emission impacts
- Changes in other air pollutants emissions, including oxides of nitrogen (NOx), carbon monoxide (CO), volatile organic compounds (VOC) and particulate matter (PM)
- Changes in modal share of transport

### 5.2.3. Environmental impacts

#### Impacts on CO₂ emissions for road transport

Services aimed at smoothing out uneven traffic flow and at reducing urban travel time (e.g. hazardous location notification and traffic signal priority) will contribute to reduced fuel consumption and therefore lower CO₂ emissions.

As shown in Table 5-22 and Figure 5-9, outputs from the modelling suggest a reduction of CO₂ emissions across all three Policy Options, although the benefits are greatest in PO3. Notably, the benefits observed in PO2 are also much higher than in PO1. Overall, though, these annual benefits are relatively limited compared to the baseline CO₂ emissions described in Section 3.

- In 2030, the annual CO₂ reductions relative to the baseline for PO1, PO2 and PO3 represent 0.1%, 0.6% and 1.2% of total baseline emissions, respectively.
In 2035, the annual CO₂ reductions relative to the baseline for PO1, PO2 and PO3 represent 0.3%, 1.1% and 1.4% of total baseline emissions, respectively.

Table 5-22. Total annual CO₂ emissions and savings relative to the baseline – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2030 (tonnes)</th>
<th>Saving relative to the baseline in 2030 (tonnes)</th>
<th>2035 (tonnes)</th>
<th>Saving relative to the baseline in 2035 (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>728.0 mn</td>
<td>-</td>
<td>708.9 mn</td>
<td>-</td>
</tr>
<tr>
<td>PO1</td>
<td>727.0 mn</td>
<td>1.0 mn</td>
<td>707.1 mn</td>
<td>1.8 mn</td>
</tr>
<tr>
<td>PO2</td>
<td>723.3 mn</td>
<td>4.7 mn</td>
<td>701.1 mn</td>
<td>7.8 mn</td>
</tr>
<tr>
<td>PO3</td>
<td>719.4 mn</td>
<td>8.5 mn</td>
<td>699.0 mn</td>
<td>9.9 mn</td>
</tr>
</tbody>
</table>

Figure 5-9. Annual reduction in CO₂ emissions from road transport, relative to the baseline – EU28

When the cost of external cost of CO₂ emissions are considered, total benefits are also highest in PO3 (see Figure 5-10). In 2030 the monetary benefits seen in PO3 are significantly larger than in PO2. However, a decrease in the rate of increasing annual savings relative to the baseline for PO3 is observed between 2030 and 2035, as the difference in C-ITS deployment starts decreasing.
The savings relative to the baseline between 2020-2030 and 2020-2035 resulting from reduced CO₂ emissions are also greatest in PO3, with present value savings of €2.8 billion by 2030 and €5.3 billion by 2035. This is in comparison to €0.7 billion and €3.2 billion by 2035, for PO1 and PO2 respectively.

**Table 5-23. Present value of CO₂ emission costs and savings relative to the baseline for EU28 – 2030 / 2035**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>PV 2020-2030</th>
<th>Saving relative to the baseline in 2030</th>
<th>PV 2020-2035</th>
<th>Saving relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>€630 bn</td>
<td>-</td>
<td>€823 bn</td>
<td>-</td>
</tr>
<tr>
<td>PO1</td>
<td>€630 bn</td>
<td>€0.3 bn</td>
<td>€824 bn</td>
<td>€0.7 bn</td>
</tr>
<tr>
<td>PO2</td>
<td>€631 bn</td>
<td>€1.5 bn</td>
<td>€827 bn</td>
<td>€3.2 bn</td>
</tr>
<tr>
<td>PO3</td>
<td>€632 bn</td>
<td>€2.8 bn</td>
<td>€829 bn</td>
<td>€5.3 bn</td>
</tr>
</tbody>
</table>
5.2.3.2. Impacts on other pollutant emissions for road transport

Other emissions are comprised of NOx, VOC and PM. Similar to the impacts on CO₂ emissions, the greatest impact on other emissions is seen in PO3 with the benefits in PO2 also much greater than in PO1 (see Table 5-24). These annual benefits are relatively limited compared to the total air pollutant emissions in the baseline.

- In 2030, the annual emissions savings relative to the baseline for PO1, PO2 and PO3 represent 0.06%, 0.2% and 0.3% of total baseline emissions, respectively.
- In 2035, the annual emissions savings relative to the baseline for PO1, PO2 and PO3 represent 0.1%, 0.3% and 0.3% of total baseline emissions, respectively.

### CO₂ emission savings for Member State examples

For three Member States from the three different country groupings, the table below shows the annual CO₂ emission per capita savings relative to the baseline, compared with the EU28 total. Each country has similar per capita savings, which increase across the policy options. Although the Netherlands is expected to experience the greatest deployment, it has the most optimistic baseline and so savings relative to the baseline are not as pronounced as for Czech Republic, which has a less optimistic baseline.

#### Present value of annual per capita CO₂ emission savings relative to the baseline for NL, CZ, PO, and EU28 – 2030 / 2035

<table>
<thead>
<tr>
<th>Country</th>
<th>PO1 Saving relative to the baseline in 2030</th>
<th>PO1 Saving relative to the baseline in 2035</th>
<th>PO2 Saving relative to the baseline in 2030</th>
<th>PO2 Saving relative to the baseline in 2035</th>
<th>PO3 Saving relative to the baseline in 2030</th>
<th>PO3 Saving relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL</td>
<td>€ 0.2</td>
<td>€ 0.3</td>
<td>€ 0.9</td>
<td>€ 1.5</td>
<td>€ 1.7</td>
<td>€ 1.9</td>
</tr>
<tr>
<td>CZ</td>
<td>€ 0.2</td>
<td>€ 0.4</td>
<td>€ 1.1</td>
<td>€ 1.8</td>
<td>€ 2.0</td>
<td>€ 2.4</td>
</tr>
<tr>
<td>PL</td>
<td>€ 0.2</td>
<td>€ 0.3</td>
<td>€ 0.7</td>
<td>€ 1.2</td>
<td>€ 1.3</td>
<td>€ 1.6</td>
</tr>
<tr>
<td>EU28</td>
<td>€ 0.2</td>
<td>€ 0.3</td>
<td>€ 0.9</td>
<td>€ 1.5</td>
<td>€ 1.6</td>
<td>€ 1.9</td>
</tr>
</tbody>
</table>
Table 5-24. Annual pollutant emissions avoided (tonnes) relative to the baseline, and % reduction from the baseline – Policy Option 1, 2 and 3 – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annual emission reduction relative to the baseline</td>
<td>% reduction from the baseline</td>
</tr>
<tr>
<td><strong>PO1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>-1 tonnes</td>
<td>0.0%</td>
</tr>
<tr>
<td>NOx</td>
<td>683 tonnes</td>
<td>0.1%</td>
</tr>
<tr>
<td>VOC</td>
<td>128 tonnes</td>
<td>0.1%</td>
</tr>
<tr>
<td><strong>PO2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>-124 tonnes</td>
<td>-0.1%</td>
</tr>
<tr>
<td>NOx</td>
<td>2,671 tonnes</td>
<td>0.3%</td>
</tr>
<tr>
<td>VOC</td>
<td>436 tonnes</td>
<td>0.5%</td>
</tr>
<tr>
<td><strong>PO3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>-286</td>
<td>-0.3%</td>
</tr>
<tr>
<td>NOx</td>
<td>4,812</td>
<td>0.5%</td>
</tr>
<tr>
<td>VOC</td>
<td>763</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

The figures below also display the annual pollutant emissions relative to the baseline. As shown, the impacts are dominated by NOx emissions savings, with PM even experiencing a slight increase in emissions relative to the baseline. This is displayed as negative savings values relative to the baseline in Figure 5-11.

Absolute annual PM emissions are decreasing in the baseline and across each policy option, however the 'in-vehicle speed limits' (VSPD) service results in an increase in PM emissions on interurban roads relative to the baseline. The DRIVE C2X study (TNO et al., 2014) found that the service would result in a smoother driving style on motorways, but on inter-urban roads the increased braking or speed changes when approaching new speed limits would result in increased PM emissions. Further studies and data on the impacts of VSPD should be carried to verify this negative impact43.

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43 For instance, it is expected that increasing vehicle automation will lead to more efficient braking and the interaction of C-ITS and automation is expected to lead to a more positive impact.
Figure 5-11. Individual pollutant emissions savings relative to the baseline for EU28 – PO1, PO2 and PO3
The monetary value of the emissions savings are taken from the Update of the Handbook on External Costs of Transport (Ricardo-AEA, TRT, TEPR, DIW Econ, CAU, 2014). These values represent the EU28 average and are kept constant over time.

- **PM**: €39,604 per tonne
- **NOx**: €10,640 per tonne
- **VOC**: €1,566 per tonne

Figure 5-12 shows that annual savings are greatest in PO3 relative to the baseline, although annual savings are greater in 2030 than in 2035 for PO3, relative to the baseline. These total annual savings are very limited compared to other environmental impacts. For example, in 2035 PO3 contributes c. €48 million in emissions savings relative to the baseline compared to c. €961 million from CO₂ emission reductions.
The cumulative savings relative to the baseline are greatest in PO3, where they amount to €0.16 billion between 2020-2030 and €0.29 billion between 2020-2035 (in present value terms). In comparison, the cumulative savings between 2020-2035 of PO1 and PO2 are €0.07 billion and €0.20 billion respectively. These are minor compared with the cumulative savings presented for CO₂ emissions and fuel consumption.

**Table 5-25. Cumulative present value of other emission costs and savings relative to the baseline for EU28 – 2030 / 2035**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>PV 2020-2030</th>
<th>Saving relative to the baseline in 2030</th>
<th>PV 2020-2035</th>
<th>Saving relative to the baseline in 2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>€186.5 bn</td>
<td>-</td>
<td>€230.8 bn</td>
<td>-</td>
</tr>
<tr>
<td>PO1</td>
<td>€186.5 bn</td>
<td>€0.03 bn</td>
<td>€230.9 bn</td>
<td>€0.07 bn</td>
</tr>
<tr>
<td>PO2</td>
<td>€186.6 bn</td>
<td>€0.09 bn</td>
<td>€231.0 bn</td>
<td>€0.20 bn</td>
</tr>
<tr>
<td>PO3</td>
<td>€186.7 bn</td>
<td>€0.16 bn</td>
<td>€231.1 bn</td>
<td>€0.29 bn</td>
</tr>
</tbody>
</table>

Considering how the different pollutants contribute to the aggregate monetary savings, Table 5-26 shows that NOx dominates these savings (the total is sometimes below NOx as a result of negative PM savings relative to the baseline). Although PM only experiences a slight increase in emissions, the high external cost associated with PM emissions results in the relatively large increases in damage costs associated with this pollutant.
Table 5-26. Total and individual pollutant emissions cumulative present value of savings, relative to the baseline, for the three policy options, for EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cumulative PV savings relative to the baseline</td>
<td>% of total</td>
</tr>
<tr>
<td><strong>PO1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>-€2.0 mn</td>
<td>-7.1%</td>
</tr>
<tr>
<td>NOx</td>
<td>€29.2 mn</td>
<td>104.9%</td>
</tr>
<tr>
<td>VOC</td>
<td>€0.6 mn</td>
<td>2.3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>€27.8 mn</td>
<td>-</td>
</tr>
<tr>
<td><strong>PO2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>-€25.0 mn</td>
<td>-27.2%</td>
</tr>
<tr>
<td>NOx</td>
<td>€114.5 mn</td>
<td>124.8%</td>
</tr>
<tr>
<td>VOC</td>
<td>€2.2 mn</td>
<td>2.4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>€91.7 mn</td>
<td>-</td>
</tr>
<tr>
<td><strong>PO3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>-€56.1 mn</td>
<td>-35.9%</td>
</tr>
<tr>
<td>NOx</td>
<td>€208.7 mn</td>
<td>133.4%</td>
</tr>
<tr>
<td>VOC</td>
<td>€3.9 mn</td>
<td>2.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>€156.5 mn</td>
<td>-</td>
</tr>
</tbody>
</table>

Other pollutant emission savings in Member State examples

The table below shows the total annual pollutant emission per capita savings for the whole EU and three Member States from three different country groupings for 2030 and 2035 under each policy option. They increase from PO1 through to PO3, although the savings for the Czech Republic are greater than for both Poland and the Netherlands. Savings for Poland are greater than for the Netherlands. The external cost assigned to NOx is highest in the Czech Republic and as NOx is impacted the most, the Czech Republic sees the greatest savings relative to the baseline.

Annual per capita pollutant emission savings relative to the baseline for NL, CZ, PO, and EU28 – 2030 / 2035

<table>
<thead>
<tr>
<th>Country</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saving relative to the baseline in 2030</td>
<td>Saving relative to the baseline in 2035</td>
<td>Saving relative to the baseline in 2030</td>
</tr>
<tr>
<td>NL</td>
<td>€ 0.01</td>
<td>€ 0.02</td>
<td>€ 0.04</td>
</tr>
<tr>
<td>CZ</td>
<td>€ 0.04</td>
<td>€ 0.07</td>
<td>€ 0.12</td>
</tr>
<tr>
<td>PL</td>
<td>€ 0.02</td>
<td>€ 0.04</td>
<td>€ 0.06</td>
</tr>
<tr>
<td>EU</td>
<td><strong>€ 0.02</strong></td>
<td><strong>€ 0.04</strong></td>
<td><strong>€ 0.06</strong></td>
</tr>
</tbody>
</table>
5.2.3.3. Summary and conclusions

Table 5-27 summarises the environmental impacts of each policy option relative to the baseline. Each policy option generates positive environmental impacts and these are greatest in PO3. The total benefits are minor compared to the total baseline values, however, and the monetary benefits of emission reductions are small compared to other impacts. Finally, the environmental impact results do not indicate a noticeable rebound effect that might result in an overall negative environmental impact as a result of any of the policy options, aside from a slight increase in PM (discussed earlier).

Table 5-27. Summary of impacts for each policy option relative to the baseline

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emission costs</td>
<td>PV 2020-2035 CO₂ emission costs avoided, -0.1% compared to the baseline</td>
<td>PV 2020-2035 CO₂ emission costs avoided, -0.4% compared to the baseline</td>
<td>PV 2020-2035 CO₂ emission costs avoided, -0.6% compared to the baseline</td>
</tr>
<tr>
<td>Other emission costs – PM, NOx, VOC</td>
<td>PV 2020-2035 other pollutant emission costs avoided, -0.0% compared to the baseline</td>
<td>PV 2020-2035 other pollutant emission costs avoided, -0.1% compared to the baseline</td>
<td>PV 2020-2035 other pollutant emission costs avoided, -0.1% compared to the baseline</td>
</tr>
</tbody>
</table>

Key:

- **Significant positive impact**
- **Small positive impact**
- **Negligible/Neutral**
- **Small negative impact**
- **Significant negative impact**
6. **COMPARISON OF POLICY OPTIONS**

In this section, we summarise and compare the evidence on the main impacts of the three policy options and make recommendations to the European Commission for policy action.

6.1. **Effectiveness**

Our assessment of the effectiveness of each policy option will consider the extent to which the specific and general objectives of the policy intervention are met. Table 6-1 below lists the general objective along with the specific objectives. The assessment criteria/indicators listed in the table are directly linked to the root causes identified in the problem definition, whose impacts are described initially in Section 5.

**Table 6-1: Objectives and impact categories**

<table>
<thead>
<tr>
<th>General Objective</th>
<th>Specific Objectives</th>
<th>Assessment criteria / indicators</th>
</tr>
</thead>
</table>
| Establish clear framework conditions to increase deployment and uptake of C-ITS services across the EU, with the aim to significantly improve road safety and traffic efficiency | Provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models | • Increased certainty about business models and its integration in CCAM  
• Improved coordination between relevant bodies |
| Reduce barriers and uncertainties to enable large-scale deployment of C-ITS       |                                                                                     | • Increased certainty about business models and its integration in CCAM  
• Increased necessary trust with regards to cyber security of C-ITS communications  
• Better public acceptance due to the consistent application of rules on privacy and protection of personal data  
• Improved coordination between relevant bodies  
• Introduction of common definition / priority of C-ITS services  
• Compatibility of communication technologies and frequency spectrum allocation to ensure proper functioning of C-ITS  
• Increased certainty with regards to minimum requirements for interoperability of C-ITS services |
| Ensure interoperability and continuity of C-ITS services across the EU             |                                                                                     | • Improved coordination between relevant bodies  
• Introduction of common definition / priority of C-ITS services  
• Compatibility of communication technologies to ensure proper functioning of C-ITS  
• Increased certainty with regards to minimum requirements for interoperability of C-ITS services  
• Increased certainty with regards to minimum requirements for compliance assessment for C-ITS services  
• Improved continuity of C-ITS services across Europe |
Additional indicators for measuring the effectiveness will include meeting indirect objectives such as:

- The level of C-ITS deployment
- The level of societal, economic and environmental benefits of C-ITS
  - Fuel consumption
  - CO₂ emissions
  - Pollutant emissions
  - Accidents
  - Urban travel time

Table 6-2 summarises the findings for each policy option regarding the extent to which the original objectives have been met, based on an analysis of the assessment criteria. It also summarises the findings for the key indirect impacts discussed above. This analysis is based on the findings presented in Section 5 - Analysis of impacts.
Table 6-2: Assessment of effectiveness of policy options compared to the baseline scenario

<table>
<thead>
<tr>
<th>Impact category</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased certainty about business models and integration of C-ITS in CCAM</td>
<td>Provision of non-binding guidelines only remove a limited number of uncertainties for businesses.</td>
<td>Provision of communications specifications removing additional uncertainties for businesses. Further integration of C-ITS into CCAM addressed through stakeholder platform.</td>
<td>The V2V mandate, combined with deployment coordination, will strongly speed up deployment and network effects, providing increased certainty for investments.</td>
</tr>
<tr>
<td>Improved coordination between relevant bodies</td>
<td>Guidelines on governance structures for security and compliance assessment bodies will help with coordination within MS. Since these bodies do not have to be set up or reported to the Commission the EU level coordination will be limited. With regards to EU-wide coordination of stakeholders and bodies, the set-up of a stakeholder platform will have significant impacts.</td>
<td>The additional requirement to report bodies set up for security and compliance assessment to the Commission could further improve coordination across Europe, under the premise that they are voluntarily set up. Enhanced deployment coordination will further improve coordination at EU level.</td>
<td>In addition to PO2 this foresees a mandatory set-up of bodies which will ensure that all Member States have relevant bodies in place. Depending on the coordination by the Commission this could have significant additional impacts on overall coordination between relevant bodies.</td>
</tr>
</tbody>
</table>

Specific Objective 1: Provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models
### Specific Objective 2: Reduce barriers and uncertainties to enable large-scale deployment of C-ITS

<table>
<thead>
<tr>
<th>Impact category</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased certainty about business models and its integration in CCAM</td>
<td>Limited impact, see above</td>
<td>Weakly positive impact, see above</td>
<td>Weakly positive impact, see above</td>
</tr>
<tr>
<td>Increased necessary trust with regards to cyber security of C-ITS communications</td>
<td>The non-binding nature of security guidelines limits their effect on trust in C-ITS services due to cyber security concerns. Where applied, the impact will be positive.</td>
<td>Strong measures to reduce barriers related to cyber security by putting security policy into law. It is expected that this approach will have a significant impact on trust in C-ITS services.</td>
<td>The assignment of legal bodies is likely to ensure the necessary coordination and oversight of security issues, thus ensuring that concerns around security are reduced to a minimum. Strongest impact on trust in C-ITS communications.</td>
</tr>
<tr>
<td>Better public acceptance due to the consistent application of rules on privacy and protection of personal data</td>
<td>Provision of non-binding application guidelines for the GDPR in the context of C-ITS will remove some of the uncertainties though due to the non-binding nature this measure will result in only in small impacts on public acceptance.</td>
<td>Putting application specifications for the GDPR into law, will further remove barriers and increase public acceptance by ensuring compliance with the GDPR for C-ITS. Establishment of clear purposes for lawfully processing personal data for traffic safety and efficiency will alleviate some of the concerns related to personal data use.</td>
<td>Lawfully processing data based on legal obligation or public interest, will further remove barriers and increase public acceptance by ensuring compliance with the GDPR for C-ITS.</td>
</tr>
<tr>
<td>Improved coordination between relevant bodies</td>
<td>Weakly positive impact, see above</td>
<td>Strongly positive impact, see above</td>
<td>Strongly positive impact, see above</td>
</tr>
<tr>
<td>Impact category</td>
<td>PO1</td>
<td>PO2</td>
<td>PO3</td>
</tr>
<tr>
<td>-----------------</td>
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</tr>
<tr>
<td>Introduction of common definition / priority of C-ITS services</td>
<td>Non-binding guidelines to support the provision of services as defined in the list of Day1 services will be an important step in providing a common definition of C-ITS services and emphasises the focus on Day 1 services. While the availability of such guidelines will have a positive impact, the application of common C-ITS service definition will be limited to where it is voluntarily applied.</td>
<td>The definition of Day 1 services list in specifications and the requirement for C-ITS stations to be compatible with all Day 1 services will ensure that everywhere where C-ITS services are applied common definitions are followed.</td>
<td>No additional measures on common definitions are covered in PO3 beyond those in PO2.</td>
</tr>
<tr>
<td>Compatibility of communication technologies to ensure proper functioning of C-ITS</td>
<td>Reference to existing standards on interoperability and EU-wide service profiles in non-binding guidelines will have limited, though positive impact on interoperability. A mandate to EU level standardisation organisations of services beyond the Day 1 list, will make sure that standards are in place to ensure interoperability in the future, however, this measure will only have an impact in the long term.</td>
<td>A mandate of compliance with existing standards on interoperability and EU wide service profiles of Day 1 services will have a significantly stronger impact on interoperability. Introducing a possibility to update specifications e.g. through a review clause will ensure that technological developments can be reflected.</td>
<td>No additional measures with regards to interoperability are covered in PO3 beyond those in PO2.</td>
</tr>
<tr>
<td>Increased certainty with regards to minimum requirements for interoperability of C-ITS services</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Specific Objective 3: Ensure interoperability and continuity of C-ITS services across the EU**

<table>
<thead>
<tr>
<th></th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved coordination between relevant bodies</td>
<td>Weakly positive impact, see above</td>
<td>Strongly positive impact, see above</td>
<td>Strongly positive impact, see above</td>
</tr>
<tr>
<td>Introduction of common definition / priority of C-ITS services</td>
<td>Weakly positive impact, see above</td>
<td>Strongly positive impact, see above</td>
<td>Strongly positive impact, see above</td>
</tr>
<tr>
<td>Compatibility of communication technologies to ensure proper functioning of C-ITS</td>
<td>Limited impact, see above</td>
<td>Strongly positive impact, see above</td>
<td>Strongly positive impact, see above</td>
</tr>
</tbody>
</table>
## Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
<thead>
<tr>
<th>Impact category</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased certainty with regards to minimum requirements for interoperability of C-ITS services</td>
<td>Non-binding guidelines on the compliance assessment process and to assign roles and responsibilities, will slightly increase certainty, however, the impacts will be limited.</td>
<td>Providing a definition of compliance assessment criteria for Day 1 C-ITS services and the approval process for C-ITS stations in specifications will provide the highest level of certainty around the compliance assessment. Defining in the specifications the requirements for roles/bodies needed for the approval process will furthermore help ensure compliance. Limitations to the level of compliance will stem from the voluntary nature of setting up bodies in charge.</td>
<td>The assignment of roles for compliance assessment to legal bodies will further improve compliance and reduce uncertainty by ensuring the setup of legal bodies.</td>
</tr>
<tr>
<td>Improved continuity of C-ITS services across Europe</td>
<td>Measures such as coordination of stakeholders through a stakeholder platform, MoUs with key stakeholders and an improvement of the enabling conditions through the provision of deployment funding will improve the continuity of services across Europe. Deployment limited to voluntary cases which will limit the impact.</td>
<td>Enhanced deployment coordination and funding will have an additional level of impact on continuity compared to PO1, though deployment will still be limited to voluntary cases.</td>
<td>The introduction of mandatory deployment of V2V communication will have a significant positive impact on continuity.</td>
</tr>
</tbody>
</table>
## General Objective: Increase deployment and uptake

<table>
<thead>
<tr>
<th>Impact category</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deployment/uptake levels</td>
<td>Limited impacts compared to the baseline, mainly due to additional funding and stakeholder coordination. Between 2020 and 2035, an extra 35.3 million vehicles (new vehicles plus retrofits via personal C-ITS devices) and 94,000 RSUs equipped relative to the baseline.</td>
<td>Substantial increase in deployment from PO1 due to a significant increase of certainty around the requirements/specifications for C-ITS services which will make the deployment more attractive and ensure interoperability. Since deployment is voluntary the uptake will be limited. Between 2020 and 2035, an extra 137.0 million vehicles (new vehicles plus retrofits via personal C-ITS devices) and 276,000 RSUs equipped relative to the baseline.</td>
<td>Strong positive impact on deployment/uptake levels from PO2, mainly due to the mandatory deployment of V2V communication. This is also expected to trigger enhanced infrastructure uptake. Between 2020 and 2035, an extra 141.9 million vehicles (new vehicles plus retrofits via personal C-ITS devices) and 322,000 RSUs equipped relative to the baseline.</td>
</tr>
</tbody>
</table>

## Indirect Objective: Fully access societal, economic and environmental benefits of C-ITS

<table>
<thead>
<tr>
<th>Impact category</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel consumption</td>
<td>Limited impact, see discussion of indirect impacts (Section 5.2). PV 2020-2035 fuel consumption costs reduced, -0.1% compared to the baseline.</td>
<td>Positive impact, see discussion of indirect impacts (Section 5.2). PV 2020-2035 fuel consumption costs reduced, -0.4% compared to the baseline.</td>
<td>Positive impact, see discussion of indirect impacts (Section 5.2). PV 2020-2035 fuel consumption costs reduced, -0.7% compared to the baseline.</td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>Limited impact, PV 2020-2035 CO₂ emission costs avoided, -0.1% compared to the baseline.</td>
<td>Limited impact, PV 2020-2035 CO₂ emission costs avoided, -0.1% compared to the baseline.</td>
<td>Positive impact, PV 2020-2035 CO₂ emission costs avoided, -0.6% compared to the baseline.</td>
</tr>
<tr>
<td>Pollutant emissions – PM, NOₓ, VOC</td>
<td>Limited impact, see discussion of indirect impacts (Section 5.2). PV 2020-2035 other pollutant emission costs avoided, -0.0% compared to the baseline.</td>
<td>Limited impact, see discussion of indirect impacts (Section 5.2). PV 2020-2035 other pollutant emission costs avoided, -0.1% compared to the baseline.</td>
<td>Limited impact, see discussion of indirect impacts (Section 5.2). PV 2020-2035 other pollutant emission costs avoided, -0.1% compared to the baseline.</td>
</tr>
<tr>
<td>Accidents</td>
<td>Positive impact, see discussion of indirect impacts (Section 5.2). PV 2020-2035 accident costs avoided, -1.0% compared to the baseline</td>
<td>Positive impact, see discussion of indirect impacts (Section 5.2). PV 2020-2035 accident costs avoided, -3.5% compared to the baseline.</td>
<td>Strongly positive impact, see discussion of indirect impacts (Section 5.2). PV 2020-2035 accident costs avoided, -5.0% compared to the baseline.</td>
</tr>
<tr>
<td>Impact category</td>
<td>PO1</td>
<td>PO2</td>
<td>PO3</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Urban travel time</td>
<td>Limited impact, see discussion of indirect impacts (Section 5.2). Increased travel time savings relative to baseline between 2020 and 2035 (+ 0.03%).</td>
<td>Weakly positive impact, see discussion of indirect impacts (Section 5.2). Increased travel time savings relative to baseline between 2020 and 2035 (+0.16%).</td>
<td>Positive impact, see discussion of indirect impacts (Section 5.2). Increased travel time savings relative to baseline between 2020 and 2035 (+0.42%).</td>
</tr>
</tbody>
</table>
Figure 6-1 shows the total indirect benefits against its components under each policy option. The accident cost avoided is by far the largest benefit of C-ITS uptake. This is true across all three policy options. Between 2020 and 2035, it amounts to €15.0 billion, €53.4 billion and €76.9 billion in present value terms (or costs saved) compared to the baseline for PO1, PO2, and PO3 respectively.

The value of fuel savings is the second most important impact modelled in the in PO1 and PO2. It is a private benefit rather than a societal benefit. Between 2020 and 2035, it amounts to €2.5 billion, €11.2 billion and €18.2 billion in present value cumulative benefits (or costs saved) compared to the baseline for PO1, PO2, and PO3 respectively.

Urban travel time savings is the third highest impact modelled in PO1 and PO2, but the second most important impact in PO3. Between 2020 and 2035, it amounts to €2.0 billion, €10.8 billion and €28.2 billion in present value cumulative benefits (or costs saved) compared to the baseline for PO1, PO2, and PO3 respectively. These are relatively modest impacts compared to those in our deployment scenarios annex (Annex C) because the policy options include only Day 1 C-ITS services.

Finally, as discussed in section 5.2.3, environmental impacts are some of the less significant impacts modelled in the study. This is mainly because the environmental baseline is already quite strong and effects outside of C-ITS adoption will have stronger impact on reducing environmental externalities for road transport. Nevertheless, there are positive environmental impacts.

**Figure 6-1: Composition of modelled cumulative benefits relative to baseline for the EU28 (PV terms) – PO1, PO2, PO3**
All Policy Options are very diverse in the ways in which they address the root causes to ensure that comprehensive framework conditions to increase deployment and uptake of C-ITS services across the EU are set. As the analysis above shows, Policy Option 3 has the most positive impacts across almost all assessment indicators when it comes to effectiveness.

For **Specific Objective 1** (Provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models) Policy Option 1 has only limited impacts with regards to reducing uncertainty about business models and integration of C-ITS into CCAM while both Policy Option 2 and Policy Option 3 have more positive impacts, by generally providing more certainty around specifications through binding measures. While only indirectly considered for
the development of specifications and standards, automation and how C-ITS will fit in is not explicitly covered by any of the policy options, which will lead to some limitations in addressing this root cause, although it can be considered under the stakeholder platform in PO2 and PO3. With regards to coordination between bodies, Policy Option 1 shows significant positive impacts, through the introduction of a stakeholder platform. This is further increased by enhanced deployment coordination in Policy Options 2 and 3. In addition, Policy Option 2 and 3 show more binding requirements regarding reporting on bodies set up for security and compliance assessment up until mandatory set-up of bodies (Policy Option 3). These measures will generally encourage coordination between relevant bodies across Europe. Thus, for this objective, Policy Options 2 and 3 are expected to be equally effective.

Specific Objective 2 (Reduce barriers and uncertainties to enable large-scale deployment of C-ITS) is addressed by all of the policy options (most effectively by Policy Option 3 and least effectively by Policy Option 1). Trust with regards to cyber security is increased across all Policy Options, although the impact of Policy Option 1 is limited due to non-binding guidelines on the European Union C-ITS Security Credential Management System (EU CCMS). The effectiveness is increased in Policy Option 2 through putting the EU CCMS into law. Finally, the assignment of legal bodies in Policy Option 3 will ensure the necessary coordination and oversight of security issues, thus reducing concerns around security to a minimum. This makes Policy Option 3 even more effective than Policy Option 2.

Public acceptance due to the consistent application of rules on privacy and protection of personal data is increased across all policy options. Non-binding guidelines on the GDPR complemented with the establishment of purposes for lawfully processing personal data for traffic safety and efficiency in Policy Option 1 are already expected to have significant effectiveness in terms of public acceptance. The effectiveness further increases through putting application specifications for the GDPR into law in Policy Option 2. This is further increased in Policy Option 3, as a formal legal basis for processing personal data is created.

Common definitions/priorities of C-ITS services are introduced in all policy options. In Policy Option 1 these are less effective as they are non-binding, while in Policy Option 2 the definitions/specifications become binding and the measure thus more effective. No additional measures are introduced for Policy Option 3, thus the effectiveness is assumed to be the same as Policy Option 2 with a strongly positive impact.

Compatibility of communication technologies and interoperability of C-ITS services is addressed by all policy options. Policy Option 1 however, is expected to only have a limited impact compared to the baseline as it only refers to existing standards without any obligations. In Policy Option 2 these standards become mandatory and thus a high level of compatibility/interoperability is ensured. Policy Option 3 does not include any further measures and thus shows the same effectiveness.

Together with the above assessment of impact on certainty around business models and CCAM integration as well as coordination between relevant bodies, Specific Objective 2 is met best by Policy Option 3, which shows highest effectiveness.

Finally, Specific Objective 3 (Ensure interoperability and continuity of C-ITS services across the EU) is addressed by all policy options with similar patterns as observed for the other two specific objectives. As already outlined above coordination increases from Policy Option 1 to 3. Further improvements to ensure interoperability and continuity stem from common definitions for C-ITS services and standards on interoperability. The effectiveness of the measures covered under each policy option increases from Policy Option 1 to 2. Due to the lack of additional measures covered for these root causes, Policy Option 2 shows the same effectiveness as Policy Option 3.

Regarding the uncertainties around the minimum requirements for compliance assessment of C-ITS services, Policy Option 1 is least effective, with non-binding guidelines. Policy Option 2 is significantly more effective, by providing a definition of compliance assessment criteria for Day 1 C-ITS services and the approval process for
C-ITS stations in specifications. Furthermore, the requirements for roles/bodies needed for the approval process will increase effectiveness. Additional impacts on effectiveness will result from the assignment of roles for compliance assessment to legal bodies under Policy Option 3.

While not specifically mentioned as a root cause in the problem tree, the improved continuity of C-ITS services across Europe is an important success criterion for meeting the specific objective. Under Policy Option 1, measures such as coordination of stakeholders through a stakeholder platform, MoUs with key stakeholders and increased deployment funding will have a positive impact on voluntary deployment of C-ITS services across Europe. This is further increased in Policy Option 2 through enhanced deployment coordination and funding. While in Policy Option 1 and 2 deployment is only voluntary, Policy Option 3 introduces a mandate for deployment of V2V communication which will have a significant positive impact on continuity. For this reason, Policy Option 3 best meets this specific objective.

All the direct impacts explained above will contribute towards the **General Objective** of increasing deployment and uptake of C-ITS. In line with the observations for the Specific Objectives, the effectiveness increases from Policy Option 1 to 3. As the impacts of C-ITS services scale with deployment, the effectiveness of the policy options in terms of delivering benefits (such as reduced accidents, fuel consumption, CO₂ emissions, pollutant emissions and travel time) increases from Policy Option 1 to Policy Option 3.
6.2. **Efficiency (cost effectiveness)**

Efficiency is the measure of cost for which a certain amount of benefit can be achieved. The modelled costs around the policy options are all equipment costs – for new vehicles, personal C-ITS devices, and related infrastructure costs for new roadside units, upgraded roadside units, and central C-ITS subsystems. When these costs are compared around the indirect benefits modelled (accidents, urban travel time, fuel, CO₂ emissions and air pollutants), Policy Option 3 shows the strongest net benefits. Under PO3, the present value of net benefits between 2020 and 2035 are €96.5 billion (€36.8 billion between 2020 and 2030). Under Policy Option 2, these are moderately lower: €59.8 billion for 2020-2035 and €20.5 billion for 2020-2030. Under Policy Option 1, these net benefits are considerably lower: €15.4 billion for 2020-2035 and €5.0 billion for 2020-2030.

**Figure 6-2: Net cumulative benefits relative to baseline for the EU28 (PV terms)**

Table 6-3 below summarises each category of equipment costs (against the total equipment cost) that make up modelled costs. Costs increase significantly between Policy Option 1 and Policy Option 2, and then again between Policy Option 2 and Policy Option 3.

- Under PO1, increased expenditure relative to the baseline is 27.7 percent in PV terms between 2020-2035.
- Under PO2, the increased expenditure relative to the baseline would be 108 percent over that period.
- Under PO3, the increased expenditure relative to the baseline would be 182.8 percent.

The increased costs are balanced against a nearly equally significant increase in benefits as we move from Policy Option 1 through to Policy Option 3. However, there is a significant leap in the proportion of net benefits between Policy Option 1 and 2 (a 260 percent increase), while there is a lower increase in net benefits between Policy Option 2 and 3 (a 62 percent increase). From this perspective, Policy Option 2 is the most efficient choice.
Table 6-3: Efficiency of policy options relative to the baseline

<table>
<thead>
<tr>
<th></th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Vehicle Equipment costs</td>
<td>€2.9 bn</td>
<td>€12.8 bn</td>
<td>€23.6 bn</td>
</tr>
<tr>
<td>(PV 2020-2035)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal C-ITS Device costs</td>
<td>€0.9 bn</td>
<td>€3.8 bn</td>
<td>€5.9 bn</td>
</tr>
<tr>
<td>(PV 2020-2035)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgraded RSU costs (PV</td>
<td>€0.3 bn</td>
<td>€0.5 bn</td>
<td>€0.4 bn</td>
</tr>
<tr>
<td>2020-2035)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New RSU costs (PV 2020-2035)</td>
<td>€0.1 bn</td>
<td>€1.2 bn</td>
<td>€1.5 bn</td>
</tr>
<tr>
<td>Central sub-systems costs</td>
<td>€0.7 bn</td>
<td>€0.9 bn</td>
<td>€0.9 bn</td>
</tr>
<tr>
<td>(PV 2020-2035)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total equipment costs (PV</td>
<td>€4.9 bn</td>
<td>€19.1 bn</td>
<td>€32.3 bn</td>
</tr>
<tr>
<td>2020-2035)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accident reduction benefits</td>
<td>€15.0 bn</td>
<td>€53.4 bn</td>
<td>€76.9 bn</td>
</tr>
<tr>
<td>Time saved benefits</td>
<td>€2.0 bn</td>
<td>€10.8 bn</td>
<td>€28.2 bn</td>
</tr>
<tr>
<td>CO₂ emission benefits</td>
<td>€0.7 bn</td>
<td>€3.2 bn</td>
<td>€5.3 bn</td>
</tr>
<tr>
<td>Other emissions benefits</td>
<td>€0.1 bn</td>
<td>€0.2 bn</td>
<td>€0.3 bn</td>
</tr>
<tr>
<td>Fuel saving benefits</td>
<td>€2.5 bn</td>
<td>€11.2 bn</td>
<td>€18.2 bn</td>
</tr>
<tr>
<td>Total Benefits (PV 2020-2035)</td>
<td>€20.3 bn</td>
<td>€78.9 bn</td>
<td>€128.9 bn</td>
</tr>
<tr>
<td>% modelled costs incurred by</td>
<td>76.9%</td>
<td>86.8%</td>
<td>91.2%</td>
</tr>
<tr>
<td>private sector (PV 2020-2035)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% modelled costs incurred by</td>
<td>23.1%</td>
<td>13.2%</td>
<td>8.8%</td>
</tr>
<tr>
<td>public sector (PV 2020-2035)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total net benefits (PV</td>
<td>€15.4 bn</td>
<td>€59.8 bn</td>
<td>€96.5 bn</td>
</tr>
<tr>
<td>2020-2035)</td>
<td></td>
<td></td>
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</tbody>
</table>

We have not modelled administrative costs, however these have been discussed in Section 5.2.2.2. As compliance under PO1 is voluntary, stakeholders could choose not to comply if they believed the administrative burden was high relative to their benefits gained. Thus, such costs are insignificant under PO1.

Under PO2, the key compliance costs would be adherence to the Certificate and Security Policy for deployment projects and MS and compliance assessment activity for deployment projects. Such costs are likely to be very low relative to the costs of equipment incurred for infrastructure by Member States and deployment projects. Compared to the cost sensitivity calculated earlier, any increases in compliance costs here would have very limited impact, if any.

Under PO3, any administrative burdens would be the same as under PO2.
6.3. **Coherence**

In assessing the coherence of the proposed policy options, we considered the following aspects:

- Internal coherence
- Coherence in relation to relevant EU legislation
- Coherence in relation to the wider EU strategies

### 6.3.1. **Internal coherence**

Depending on the policy option, the intervention will be closely linked to the ITS Directive, either as associated guidance under Priority Area IV (Linking the vehicle with the transport infrastructure) or as a Delegated Act under the Directive. This is in line with previous Delegated Acts under Priority Area I (Optimal use of road, traffic and travel data) and Priority Area III (ITS Road safety and security applications).

With regards to internal coherence within the ITS Directive there are two aspects to consider. One is the extent to which the priority actions for Priority Area IV, as set out in Annex I of the Directive, are covered by the policy options. The other is the strength of the link to the principles for specifications and deployment of ITS in Annex II of the ITS Directive.

Priority Area IV covers the development of specifications and standards for linking vehicles with the transport infrastructure. This includes the definition of necessary measures to integrated different ITS applications on an open in-vehicle platform based on the identification of functional requirements of existing or planned ITS applications or the definition of necessary measures to further progress the development and implementation of cooperative systems. Policy Options 1 to 3 are all in line with the actions set out in the Annex of the ITS Directive, however the level of alignment differs. Policy Option 1 only provides non-binding guidance referencing existing standards and definitions, which only has limited effect in terms of ensuring common specifications and standards across Europe. Thus, the internal coherence is limited. Policy Option 2 on the other hand goes an important step further in terms of internal coherence by including Day 1 service definitions in specification. Furthermore, it mandates compliance with existing standards on interoperability and EU-wide service profiles. This ensures that actions are taken to link the vehicle with the infrastructure. Finally, Policy Option 3 goes beyond a delegated act by mandating V2V communication in new vehicles. This requires an additional initiative as indicated in Article 6(2) of the ITS Directive. The approach could be similar to the deployment of the eCall in-vehicle system (mandated under the type-approval regulation by Regulation (EU) 2015/75844 amending Directive 2007/46/EC45) under Priority Area III: road safety and security applications.

The principles for specifications and deployment of ITS in Annex II relevant for this assessment are the following:

- Support continuity of services: ensure seamless services across the Union
- Deliver interoperability: ensure that systems and the underlying business processes have the capacity to exchange data and to share information and knowledge to enable effective ITS service delivery
- Support backward compatibility: ensure, where appropriate, the capability for ITS systems to work with existing systems that share a common purpose, without hindering the development of new technologies

Policy Option 1 only shows weak internal coherence as guidance to ensure interoperability or backward compatibility is non-binding and thus the link to the

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45 https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32007L0046
principles of Annex II cannot be ensured. Some impact on continuity of services under Policy Option 1 stems from activities under a stakeholder platform and MoUs. Again, these activities are voluntary and impact is expected to be limited. Policy Option 2 ensures much stronger alignment with the principles of Annex II, in particular around interoperability and backward compatibility by making definitions of C-ITS services and standards/service profiles mandatory where C-ITS is voluntarily deployed. Continuity is ensured beyond Policy Option 1 through additional enhanced deployment coordination. However, EU wide continuity is limited still as C-ITS deployment is still voluntary. This is addressed with Policy Option 3 where a mandate for the deployment of V2V communication ensures continuity across the EU.

6.3.2. Coherence with relevant EU legislation

With regards to external coherence, the main pieces of legislation to consider are the following:

- General Data Protection Regulation (EU) 2016/679 (GDPR) repealing Directive 95/46/EC which provides a comprehensive legal framework concerning personal data. In the context of C-ITS, an analysis is needed of the suitable legal basis for lawfully processing personal data.
- Directive 2002/58/EC ‘concerning the processing of personal data and the protection of privacy in the electronic communication sector’ (and proposed Regulation to repeal the Directive, as set out in COM (2017) 10). In addition to the GDPR the EU also applies sectoral data protection legislation known as the ‘ePrivacy Directive’.

In case of a mandate in new vehicles (as considered in Policy Option 3) the Directive 2007/46/EC (establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles) also has to be considered.

Policy Option 1 provides non-binding application guidelines for the GDPR in the context of C-ITS. This ensures more clarity on how the GDPR would be applied including responsibilities and requirements. Due to the voluntary nature of this measure, the impact on coherence with the GDPR is limited (with respect to ensuring compliance). Policy Option 2 foresees an adoption of application specifications for the GDPR in the context of C-ITS which would significantly improve coherence with this piece of legislation. Policy Option 3 shows the same level of coherence with the GDPR as Policy Option 2.

Policy Option 1 and 2 are both coherent with the ePrivacy Directive, as they establish purposes for lawfully processing personal data. Assuming that public interest or legal obligation can be established, Policy Option 3 also shows strong coherence.

Finally, external coherence with the vehicle type approval Directive (2007/46/EC) needs to be ensured for Policy Option 3 which includes the in-vehicle mandate. To assess coherence with this Directive, a detailed proposal for a mandate is required, thus an assessment at this stage is not possible.

6.3.3. Coherence with wider EU strategies

Section 1.3.1 sets out the policy context for C-ITS including EU level strategy documents. Strategy documents specific to C-ITS include:

- European strategy on Cooperative Intelligent Transport Systems (European Commission, 2016)
- Report from the Committee on Transport and Tourism on the EU Strategy on Cooperative Intelligent Transportation Systems (European Parliament - Committee on Transport and Tourism, 2017)

Both documents set out the high-level framework for C-ITS and call for mass-scale deployment. All three policy options contribute to this goal, albeit to varying degrees.
Policy Option 1 shows the lowest, and Policy Option 3 the highest impact on deployment and consequently coherence with these strategies.

The indirect impacts of C-ITS deployment, namely impacts on accident rates, fuel consumption/CO₂ emissions, pollutant emissions and travel time, all contribute to wider targets across the EU covered by different strategies. The Commission’s ‘Europe on the Move’ Communication (European Commission, 2017) for example includes a Strategic Action Plan on Road Safety with specific reference to connected mobility. Furthermore, the communication sets out targets for low emission mobility. The Commission’s 2011 Transport White Paper (European Commission - DG MOVE, 2011) sets the wider framework for EU transport policy highlighting the need for a single transport area (i.e. continuity) and competitive and resource efficient transport systems.

As Section 5 shows, increasing benefits are delivered from Policy Option 1 through to Policy Option 3, the latter showing the strongest positive impacts in terms of environmental, economic and safety benefits and thus most closely aligned with the targets set out in European strategy documents.

6.4. Proportionality and subsidiarity

Policy Option 1 relies on non-binding guidance and thus allows Member States and individual deployment projects to decide whether or not to comply with the provided guidelines. In this sense, PO1 is proportional to achieving the intended objective.

Policy Option 2 relies on a Delegated Act under the ITS Directive. Compliance would only be mandatory if deploying C-ITS services. While it is a much more stringent measure than PO1, the expected benefits, both direct and indirect, are also proportionally higher. Furthermore, the measures in PO2 are critical to ensuring EU-wide interoperability. Still, Member States and deployment projects have the ability to decide whether they would want to deploy C-ITS under these terms. In that sense, PO2 is proportional.

Policy Option 3 relies on a V2V mandate, which would require a different legal procedure to the Delegated act under PO2. It is as yet unclear what the steps are for this legal procedure to take effect and whether the legal criteria for this mandate can be met. In addition, PO3 imposes an obligation on OEMs for vehicles to have 100 percent of their fleets equipped over the course of one vehicle life cycle from when the policy would take effect in 2021. While some OEMs have already made announcements that they will deploy, this policy option requires them to meet certain stringent standards for privacy, security, interoperability, and continuity of services. Since PO2 already has significant direct and indirect impacts, without resorting to a V2V mandate, the proportionality and necessity of such a mandate should be carefully assessed.

6.5. Preferred option

Taking into account the balance between the above-discussed criteria, we conclude that Policy Option 2 is the preferred option for this support study, given the evidence presented. The rationale is summarised below:

- Effectiveness: Policy Option 3 is the strongest across nearly all indicators against the three specific objectives defined in our problem tree and the indirect objectives regarding deployment and other indirect benefits.
• Efficiency: Policy Option 2 is the most efficient choice. There is a significant leap in the proportion of net benefits between Policy Option 1 and 2, while there is a lower increase in net benefits between Policy Option 2 and 3.

• Coherence: Policy Option 2 offers stronger performance than Policy Option 1 on coherence. Policy Option 3 performs slightly better than Policy Option 2 with regard to coherence. For this reason, Policy Option 3 is the best choice given the information available.

• Proportionality and subsidiarity: Both Policy Option 1 and 2 are proportional – allowing Member States to self-determine the level of deployment they prefer. The enhanced benefits under PO2 are proportional to the level of control delegated to the EU from Member States. Policy Option 3 imposes a direct obligation on vehicle OEMs, which has costs (both material and political). Given that significant benefits can be achieved already under PO2 without imposing this obligation, PO2 currently performs better than PO3 on this test.

In summary, Policy Option 2 performs better against two out of the four criteria presented, and this is the option we recommend should be taken forward at present. While effectiveness and coherence, where Policy Option 3 performs best, are key considerations, the selection of Policy Option 2 does not preclude a future move to Policy Option 3 once the legal and policy avenues are better understood (and the considerations under proportionality and subsidiarity can be updated) and that future performance under PO2 is assessed.
7. **RESEARCH LIMITATIONS AND SENSITIVITY ANALYSIS**

7.1. **Research Limitations – robustness of findings**

A study such as this one that examines the future impacts of technologies not yet in place beyond early deployment has some necessary limitations in terms of the information available on potential deployment and associated costs and benefits. This uncertainty is the main research limitation of this work. To counteract this uncertainty, we have carried out an extensive review of documentation available on deployment projects, used our case study interviews and other wider stakeholder engagement activities to gather further information, and tested various policy options/deployment scenarios with different C-ITS uptake profiles between 2019 and 2035.

For example, some of our modelling assumptions are based on what we have observed today from ongoing pilot projects, or from discussions with stakeholders on their experiences. Our assessment of the potential impacts of different C-ITS service offerings is based on existing research, and in some cases, where there is no research available, an estimate based on comparable C-ITS services. Once large-scale deployment is under way, it may be that the actual impacts of the various C-ITS services are different than those suggested in this study. A related aspect to this is the fast-moving nature of the technology itself. For example, we have not modelled any benefits of time-critical safety services for personal C-ITS devices, but in the future, this technology may be available in such devices.

In the main report of this study, we only consider the deployment of Day 1 services, the majority of which are focused on improving safety. As agreed in Phase I of the C-ITS platform (European Commission, 2016), the primary purpose of Bundle 1 services is improved safety. Bundles 2 and 3, which are grouped by a common geographic dimension (motorway and urban respectively), also focus primarily on safety. Other impacts such as driving efficiencies and the corresponding emission reductions, are predominantly offered by Day 1.5 services, whose impacts are modelled in Annex C.

As detailed in Annex B, for each service we considered available information on impacts relating to traffic efficiency, fuel consumption, polluting emissions and safety. For Bundle 1 services, it was expected that non-safety impacts would be minimal, and this was confirmed by other studies that often did not consider non-safety impacts or found them to be insignificant. For example, the Drive C2X study concluded that non-safety impacts were insignificant for ‘Traffic jam ahead warning’ (TJW). More non-safety related impacts were identified in the literature for Bundle 2 and 3 services, although safety impacts remain the most common primary objective. While it should be expected that impacts from Day 1 services will be mainly safety, it is appreciated that other impacts may be underestimated due to the safety focus in existing studies.

7.2. **Simplifications for modelling purposes**

A key research limitation lies in modelling constraints where some assumptions require necessary simplifications to fit into our modelling framework. In this subsection, we describe some of the most important aspects we have simplified in our model.

- We assume C-ITS uptake rates are linear. In reality, they may be quadratic or S-shaped, but without better information on potential uptake rates, it is difficult to justify the use of a more complex function to estimate uptake. If uptake was quadratic rather than linear, both costs and benefits would accelerate jointly, but it would not affect the balance between costs and benefits. The main difference would be that net benefits are then higher because uptake is brought forward. For an S-shaped curve, the effect would be in between that of quadratic uptake and linear uptake. In addition, a differently shaped uptake rate will result in network effects being accessed at a different time than modelled here.
• The impact inputs are developed as percentage improvements at maximum effectiveness (i.e. at 100 percent deployment in infrastructure and the vehicle fleet). The actual effectiveness is then estimated through scaling this maximum effectiveness linearly to the predicted vehicle/aftermarket and infrastructure penetration rates. This, in effect, assumes that all systems are interoperable and will be able to communicate with all other equipped C-ITS stations. For that reason, our projected deployment in each scenario is for fully interoperable C-ITS. In future years, it is conceivable that C-ITS technology could improve to deliver greater impacts. However, the modelling assumes that there will be no improvement in technology/performance over the time period covered in this cost-benefit analysis (2019-2035).

• We have grouped the EU 28 countries into three country groupings, which means that deployment rates for countries in the same country grouping will be equal. Of course, some differences are introduced per country via the macroeconomic modelling, and also the extrapolation of what the deployment rates mean in absolute for each country. Related to this, we have also assumed equal uptake in new vehicles across all country groupings.

• To develop uptake rates for retrofitting C-ITS equipment to existing vehicles, a simple stock model for the EU was developed assuming an EU average scrappage age for vehicles (i.e. 15 years for light duty vehicles). In reality, the scrappage ages differ significantly from Member State to Member State which results in varying distribution of C-ITS equipment in new and retrofitted vehicles. Such differences are not reflected in our modelling.

• Another key modelling detail is the prediction of how technology costs estimated today will change over time. On the basis of stakeholder feedback and our experience in modelling various vehicle technologies, we have implemented a technology learning rate of 15 percent that applies once uptake reaches a critical mass\textsuperscript{47}. Beforehand, a more modest year-on-year reduction of 2 percent is applied for technology costs.

• We assumed the uptake of C-ITS in personal C-ITS devices (smartphones) will begin and keep pace with uptake modelled for new vehicles. In reality, if consumer demand for these technologies is very high, uptake in these devices may outpace uptake in new vehicles. Alternatively, the opposite may happen if consumer demand turns out to be low. Without any available data on these trends and the exact suitability of different technologies for different services, we have assumed uptake in line with new vehicles. And on a related note, consumers may have recourse to a wider range of personal C-ITS devices with potentially different cost profiles. Our model simplifies this by presenting only smartphone costs.

• A final key limitation of the study is that we base estimates and assumptions on observed data, patterns, trends, and/or feedback from key stakeholders. In the future, as C-ITS uptake rolls out to a wider group of countries, we may identify unique challenges for Follower and Planned Adopter countries that may suggest additional costs, or perhaps greater benefits than for the Front Runner countries who have already started to deploy. It is also possible that as uptake reaches scale even in Front Runner countries, new costs and/or new benefits are identified.

7.3. Sensitivity analysis
As discussed in Section 7.1, some of the limitations of the study are due to uncertainties around the input assumptions for the modelling. In particular, the fact that the study examines the future impacts of technologies not yet in place beyond

\textsuperscript{47} For vehicles the starting volume is set to 30 million units. For RSUs the starting volume is set to 50,000 units.
trial projects has some necessary limitations in terms of the information available on potential deployment and associated benefits. To assess the impact of uncertainties around these input parameters, we have carried out three simple sensitivity analyses assuming:

a) An increase in equipment costs of new vehicles and personal C-ITS devices by 50 percent, assessing impacts on all policy options

b) A reduction of deployment rates by 10 percent, assessing impacts on PO1 & PO2 (for a reduction in-vehicle and infrastructure deployment) and PO3 (for a reduction in infrastructure deployment)\(^{48}\)

c) A reduction of impacts of C-ITS services by 10 percent\(^ {49}\), assessing impacts on PO1, PO2, and PO3

The sensitivity analysis model runs for reduced deployment rates and a reduction in the impacts of C-ITS services have been modelled explicitly in the ASTRA/TRUST and CBA models for PO2 and PO3, the preferred policy options identified in Section 6. As PO1 was discarded, the likely sensitivity was instead estimated on the basis of the magnitude of the results of the PO2 sensitivity.

The following sections discuss the impact of changes in these parameters on the results by impact category.

### 7.3.1. Sensitivity analysis on deployment costs

As the costs of new vehicle and personal C-ITS devices dominate the equipment costs, variances in such costs will have the greatest overall cost impacts on model outcomes for each policy option. Total equipment costs, however, are small compared to total societal benefits. As shown in Table 7-1, the net PV benefit following an increase in costs by 50 percent does not decrease significantly. Under PO1, a 50 percent increase in new vehicle and personal C-ITS device costs in the model would still yield a reasonable NPV benefit of €4.0 billion from 2020-2030 and €13.5 billion from 2020-2035. Under PO2, this net benefit increases to €15.6 billion between 2020-2030 and €51.5 billion between 2020-2035. Under PO3, the net benefit is even higher, cumulating to €27.2 billion between 2020-2030 and €81.8 billion between 2020-2035. Even though the costs in PO3 would be greatest compared to the other policy options, the strong net benefit under this sensitivity calculation shows that the model results are robust to significant increases in equipment costs for new in-vehicle and personal C-ITS devices.

\(^{48}\) As in-vehicle deployment is mandatory under PO3 only the infrastructure deployment is reduced in this sensitivity.

\(^{49}\) In the main scenarios, the impact of C-ITS on safety was reduced by 10% to account for potential overlaps with the GSR Regulation. In this sensitivity, the safety impacts are further reduced by 10%.
Table 7-1. Cumulative net present value (NPV) of benefits for each policy option relative to the baseline, with and without a cost sensitivity applied, EU28

<table>
<thead>
<tr>
<th></th>
<th>PO1 2020-2030</th>
<th>PO1 2020-2035</th>
<th>PO2 2020-2030</th>
<th>PO2 2020-2035</th>
<th>PO3 2020-2030</th>
<th>PO3 2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV benefits</td>
<td>€5.0 bn</td>
<td>€15.4 bn</td>
<td>€20.4 bn</td>
<td>€59.8 bn</td>
<td>€36.8 bn</td>
<td>€96.5 bn</td>
</tr>
<tr>
<td>NPV benefits after 50% equipment cost increase</td>
<td>€4.0 bn</td>
<td>€13.5 bn</td>
<td>€15.6 bn</td>
<td>€51.5 bn</td>
<td>€27.2 bn</td>
<td>€81.8 bn</td>
</tr>
</tbody>
</table>

### 7.3.2. Sensitivity analysis on deployment rates

Sensitivity analysis is conducted on deployment rates to estimate the level of uncertainty in impacts estimated when in-vehicle and infrastructure deployment decreases by 10%. For PO3, this reflects only a decrease in infrastructure deployment due to the vehicle deployment mandate in PO3.

Table 7-2 below shows how the decrease in deployment affects costs, benefits and net benefits for PO1, PO2, and PO3 relative to the baseline.

The likely sensitivity for PO1 has been estimated as a linear extrapolation of the differences between PO2 and the PO2 deployment sensitivity. Under PO1, we estimate that a 10% decrease in deployment would change the discounted net benefits in the period from 2020 to 2035 from €15.4 billion to €11.2 billion relative to the baseline, a 27% reduction. This is due to a decrease in total costs from €4.9 billion to €4.1 billion and also an associated decrease in total benefits, from €20.3 billion to €15.3 billion.

Similarly, under PO2, we estimate that lower deployment would decrease the discounted net benefit from €59.8 billion to €43.4 billion relative to the baseline. This is a result of decreased costs and also a more significant decrease in benefits. Differences do not vary much between different types of benefits, but the CO₂ emissions, fuel consumption and urban travel time benefits are more sensitive to deployment changes.

The potential impacts under PO3 are less severe due to the V2V mandate in place, which means that in this sensitivity, only infrastructure deployment decreases. For that reason, the difference between PO3 and the sensitivity result is less than for PO2. Most of the impacts are uniform, although urban travel time savings are less affected by lower infrastructure deployment than other impact categories.
Table 7-2: EU28 sensitivity analysis for deployment rates reduced by 10%: net cumulative PV benefits relative to baseline 2020-2035 and % change between policy option and sensitivity

<table>
<thead>
<tr>
<th></th>
<th>PO1</th>
<th>PO1 - deployment sensitivity</th>
<th>% change</th>
<th>PO2</th>
<th>PO2 - deployment sensitivity</th>
<th>% change</th>
<th>PO3</th>
<th>PO3 - (infra) deployment sensitivity</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidents</td>
<td>€15.0 bn</td>
<td>€11.6 bn</td>
<td>-23%</td>
<td>€53.4 bn</td>
<td>€41.0 bn</td>
<td>-23%</td>
<td>€76.9 bn</td>
<td>€70.1 bn</td>
<td>-9%</td>
</tr>
<tr>
<td>Urban travel time</td>
<td>€2.0 bn</td>
<td>€1.5 bn</td>
<td>-26%</td>
<td>€10.8 bn</td>
<td>€8.0 bn</td>
<td>-26%</td>
<td>€28.2 bn</td>
<td>€26.8 bn</td>
<td>-5%</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>€2.5 bn</td>
<td>€1.8 bn</td>
<td>-28%</td>
<td>€11.2 bn</td>
<td>€8.0 bn</td>
<td>-28%</td>
<td>€18.2 bn</td>
<td>€15.9 bn</td>
<td>-13%</td>
</tr>
<tr>
<td>CO2 emissions</td>
<td>€0.7 bn</td>
<td>€0.5 bn</td>
<td>-29%</td>
<td>€3.2 bn</td>
<td>€2.3 bn</td>
<td>-29%</td>
<td>€5.3 bn</td>
<td>€4.6 bn</td>
<td>-13%</td>
</tr>
<tr>
<td>Pollutants</td>
<td>€0.1 bn</td>
<td>€0.1 bn</td>
<td>-20%</td>
<td>€0.2 bn</td>
<td>€0.2 bn</td>
<td>-20%</td>
<td>€0.3 bn</td>
<td>€0.3 bn</td>
<td>-9%</td>
</tr>
<tr>
<td>Total Benefits</td>
<td>€20.3 bn</td>
<td>€15.3 bn</td>
<td>-25%</td>
<td>€78.9 bn</td>
<td>€59.5 bn</td>
<td>-25%</td>
<td>€128.9 bn</td>
<td>€117.7 bn</td>
<td>-9%</td>
</tr>
<tr>
<td>Total Costs</td>
<td>€4.9 bn</td>
<td>€4.1 bn</td>
<td>-16%</td>
<td>€19.1 bn</td>
<td>€16.1 bn</td>
<td>-16%</td>
<td>€32.3 bn</td>
<td>€32.1 bn</td>
<td>-1%</td>
</tr>
<tr>
<td>Net Benefits</td>
<td>€15.4 bn</td>
<td>€11.2 bn</td>
<td>-27%</td>
<td>€59.8 bn</td>
<td>€43.4 bn</td>
<td>-27%</td>
<td>€96.5 bn</td>
<td>€85.5 bn</td>
<td>-11%</td>
</tr>
</tbody>
</table>

Note: PO1 sensitivity impacts have been estimated from the modelled changes between the PO2 and the PO2 deployment sensitivity, as this option was discarded in the previous chapter. PO2 and PO3 sensitivities have been modelled in the ASTRA/TRUST and the CBA models.

The reductions in benefits are more than proportional to the 10 percent change in deployment modelled for all but PO3 – implying that lower deployment than expected in these policy options would yield greater reductions in benefits expected. The reduction in benefits is roughly proportional in the PO3 sensitivity due to the V2V mandate in this scenario. The sensitivity of benefits to the level of deployment under PO1 and PO2 is primarily a result of the network effect, where lower deployment is predicted to have a more than proportional effect on impacts. In all cases however, net benefits are positive for all sensitivities modelled. These net benefits remain highest in PO3, with net benefits nearly twice as high as PO2 in the sensitivity modelled.
7.3.3. Sensitivity analysis on impacts

Another aspect of uncertainty with regards to modelled benefits is the estimated effects of C-ITS Day 1 services on accidents, CO₂ emissions, other pollutant emissions, urban travel time and fuel consumption. In this sensitivity test, the effects of the different C-ITS services are reduced by 10% to assess the level of certainty in modelled benefits.

Table 7-3 below summarises the change in costs and benefits under this sensitivity for the 2020-2035 period for PO1, PO2, and PO3.

Under PO1 (using a linear extrapolation from the PO2 sensitivity results), we estimate that a 10% decrease in C-ITS impacts would change the discounted net benefits in the period from 2020 to 2035 from €15.4 billion to €12.6 billion, an 18% shift. This is due to a decrease in total benefits from €20.3 billion to €17.5 billion. Costs remain the same as equipment costs are not affected by a variance in the effectiveness of C-ITS services.

Under PO2, the discounted net benefit decreases from €59.8 billion to €48.9 billion (an 18% reduction), due to lower total benefits. While the decrease in benefits is similar across the categories of impacts, accidents, fuel consumption, and CO₂ emissions are slightly more affected.

PO3 sensitivity results are broadly similar to those for PO2, with the exception that the decrease in benefits are milder than under PO2. Discounted net benefits are 16% lower than PO3 in this sensitivity, decreasing from €96.5 billion to €80.7 billion.

50 While the effects of C-ITS safety services have been reduced by 10% to account for any overlap with the GSR, yielding the results presented in Section 5, in this sensitivity check all impacts are reduced 10% across the board from those used in the main modelling scenarios.
Table 7-3: EU28 sensitivity analysis for C-ITS impacts reduced by 10%: net cumulative PV benefits relative to baseline 2020-2035 and % change between policy option and sensitivity

<table>
<thead>
<tr>
<th>Impact Category</th>
<th>PO1 Impact Sensitivity</th>
<th>% Change</th>
<th>PO2 Impact Sensitivity</th>
<th>% Change</th>
<th>PO3 Impact Sensitivity</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidents</td>
<td>€15.0 bn</td>
<td>-14%</td>
<td>€53.4 bn</td>
<td>-14%</td>
<td>€76.9 bn</td>
<td>-13%</td>
</tr>
<tr>
<td>Urban travel time</td>
<td>€2.0 bn</td>
<td>-11%</td>
<td>€10.8 bn</td>
<td>-11%</td>
<td>€28.2 bn</td>
<td>-11%</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>€2.5 bn</td>
<td>-15%</td>
<td>€11.2 bn</td>
<td>-15%</td>
<td>€18.2 bn</td>
<td>-13%</td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>€0.7 bn</td>
<td>-15%</td>
<td>€3.2 bn</td>
<td>-15%</td>
<td>€5.3 bn</td>
<td>-13%</td>
</tr>
<tr>
<td>Pollutants</td>
<td>€0.1 bn</td>
<td>-10%</td>
<td>€0.2 bn</td>
<td>-10%</td>
<td>€0.3 bn</td>
<td>-9%</td>
</tr>
<tr>
<td>Total Benefits</td>
<td>€20.3 bn</td>
<td>-14%</td>
<td>€78.9 bn</td>
<td>-14%</td>
<td>€128.9 bn</td>
<td>-12%</td>
</tr>
<tr>
<td>Total Costs</td>
<td>€4.9 bn</td>
<td>0%</td>
<td>€19.1 bn</td>
<td>0%</td>
<td>€32.3 bn</td>
<td>0%</td>
</tr>
<tr>
<td>Net Benefits</td>
<td>€15.4 bn</td>
<td>-18%</td>
<td>€59.8 bn</td>
<td>-18%</td>
<td>€96.5 bn</td>
<td>-16%</td>
</tr>
</tbody>
</table>

Note: PO1 sensitivity impacts have been estimated from the modelled changes between the PO2 and the PO2 deployment sensitivity, as this option was discarded in the previous chapter. PO2 and PO3 sensitivities have been modelled in the Astra/TRUST and the CBA models.

The reduction in modelled benefits is slightly more than proportional to the 10% decrease in C-ITS impacts, although the reductions in benefits are much smaller than those in the deployment sensitivity. While the reductions in impact are broadly similar across impact categories, benefits for accidents, fuel consumption, and CO₂ emission benefits are slightly more sensitive to lower C-ITS effectiveness. The slightly smaller decline in the PO3 sensitivity compared to PO2 implies that wider deployment under PO3 helps to counteract reduced C-ITS service effectiveness. As with the deployment sensitivities, net benefits in the impact sensitivity remain positive for all policy options, with the highest net benefits under PO3.
7.3.4. **Summary of sensitivity analysis**

Sensitivity analysis for the deployment and impacts of C-ITS still show positive net benefits between 2020 and 2035 under all policy options, despite yielding lower benefits overall. For PO2 and PO3, the preferred policy options, these are shown in the following two figures in comparison to the policy scenarios.

Figure 7-1 below shows how the net cumulative benefits for PO2, PO3 and their deployment sensitivities evolve year by year through to 2035, relative to the baseline. There is no overlap in the uncertainty bands for the policy options in this sensitivity, and the narrower uncertainty band for PO3 is due to the fact that only infrastructure deployment uncertainty is considered, and not in-vehicle deployment, which would be under a mandate.

**Figure 7-1: EU28 net cumulative benefits relative to baseline 2020-2035 – Deployment sensitivity**

In addition, Figure 7-2 shows PO2 and PO3 net cumulative benefits relative to the baseline, along with the difference in the impact sensitivity for each. As in the deployment sensitivity, there are no overlaps in the uncertainty range for the two policy options.
Overall, under PO1, discounted net cumulative benefits between 2020 and 2035 fall from €15.4 billion to €11.2 billion and €12.6 billion under the deployment and impact sensitivities, respectively. These are approximated using linear extrapolations from PO2 sensitivities, and for PO2 discounted net cumulative benefits decrease from €59.8 billion to €43.4 billion and €48.9 billion under the deployment and impact sensitivities. Finally, under PO3, net benefits fall from €96.5 billion to €85.5 billion and €80.7 billion under the deployment and impact sensitivities.

Overall, cumulative discounted net benefits between 2020 and 2035 remain positive for all policy options. However, the net benefits show a more than proportional decrease when deployment reduces by 10%, due to the network effect. With regards to the sensitivity modelling lower effectiveness of C-ITS services on accidents, CO\textsubscript{2}, etc. the resulting modelled impacts still show a more than proportional decrease from the main policy scenario, but less severe than that under the deployment sensitivity. Notably, reduced PO3 net benefits under the impact sensitivity are slightly lower than under PO2, implying that greater deployment under PO3 translates to greater resilience to reduced C-ITS service impacts.
8. Monitoring and evaluation

8.1. Introduction and monitoring mechanisms

This section will be based on the preferred policy option identified in Section 6 – Policy Option 2. As the provisions of the Delegated Act are not imposed in a mandatory fashion, monitoring is relevant for the deployment projects (both existing and new) that do decide to deploy C-ITS services. Given that compliance assessments are an important theme for sets of policy measures under PO2, we propose that monitoring and evaluation for all aspects of the policy take place under compliance assessment activities.

8.2. Monitoring actions

Compliance assessments would track how stakeholders involved in a C-ITS deployment project are adhering to the requirements set out in the Delegated Act by key policy measure theme (see Table 8-1).

Table 8-1: Monitoring actions by theme

<table>
<thead>
<tr>
<th>Policy Measure Theme</th>
<th>Policy Measure</th>
<th>Proposed Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Privacy and protection of personal data, including access to data and data quality</td>
<td>Binding application specifications for the GDPR in the context of C-ITS, including the responsibilities and requirements.</td>
<td>Compliance assessment processes annually audit C-ITS deployment projects for adherence to GDPR privacy and data protection requirements.</td>
</tr>
<tr>
<td></td>
<td>Establishing purposes for lawfully processing personal data as traffic safety &amp; efficiency information, with limitations (no commercial or law enforcement use).</td>
<td>Compliance assessment processes annually audit C-ITS deployment projects for adherence to lawful purposes for processing personal data.</td>
</tr>
<tr>
<td>Security</td>
<td>Contents of the CP/SP become part of EU law, specifying C-ITS security requirements &amp; procedures.</td>
<td>Compliance assessment processes annually audit C-ITS deployment projects for adherence to CP/SP requirements.</td>
</tr>
<tr>
<td></td>
<td>Possibility to update the CP/SP, e.g. through a review clause.</td>
<td>Use of the new C-ITS Platform set up as part of the Continuity policy measure to review the CP/SP requirements on a yearly basis, making recommendations for updates to the Commission.</td>
</tr>
<tr>
<td></td>
<td>Definition of needed roles in CP/SP is put into EU law, plus a requirement to provide information to the Commission on the bodies /authorities in charge for each Member State to monitor compliance with the CP/SP.</td>
<td>The Commission to set up a central register for information provided by Member States on bodies and authorities in charge for each Member State to monitor compliance with the CP/SP.</td>
</tr>
<tr>
<td>Policy Measure Theme</td>
<td>Policy Measure</td>
<td>Proposed Action</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Interoperability</td>
<td>Definition of Day 1 services list in specifications.</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>C-ITS stations to support all Day 1 Services.</td>
<td>Compliance assessment processes annually audit C-ITS deployment projects for the ability of stations to support all Day 1 services.</td>
</tr>
<tr>
<td></td>
<td>Updatability of services and their definitions, e.g. through a review clause.</td>
<td>Use of the new C-ITS Platform set up as part of the Continuity policy measure to review the list of services and their definitions on a yearly basis, making recommendations for updates to the Commission.</td>
</tr>
<tr>
<td></td>
<td>Mandate compliance with existing standards on interoperability in specifications.</td>
<td>Compliance assessment processes annually audit C-ITS deployment projects for adherence to interoperability standards.</td>
</tr>
<tr>
<td></td>
<td>Mandate compliance with EU-wide service profiles of Day 1 services in specifications.</td>
<td>Compliance assessment processes annually audit C-ITS deployment projects for compliance with Day 1 service profiles.</td>
</tr>
<tr>
<td></td>
<td>Issue a Mandate to EU level standardisation organisations for standardisation of services beyond the Day 1 list.</td>
<td>Use of the new C-ITS Platform set up as part of the Continuity policy measure to monitor progress by EU standardisation organisations on services standardisation on a quarterly basis.</td>
</tr>
<tr>
<td>Compliance assessment</td>
<td>Definition of compliance assessment criteria for Day 1 C-ITS services in specifications of Delegated Act.</td>
<td>N/A – other areas in the table define these criteria for each area of compliance.</td>
</tr>
<tr>
<td></td>
<td>Approval process for C-ITS stations provided in the specifications</td>
<td>Compliance assessment processes annually audit organisations tasked with providing approval for compliance with the designated approval process.</td>
</tr>
<tr>
<td>Policy Measure Theme</td>
<td>Policy Measure</td>
<td>Proposed Action</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td>Define in the specifications requirements for needed roles in relation to the approval process of C-ITS stations + information to the Commission on the bodies / authorities in charge if they have been set up.</td>
<td>The Commission to set up a central register for information provided by Member States on bodies and authorities in charge for each Member State to provide approval for C-ITS stations.</td>
</tr>
<tr>
<td>Continuity</td>
<td>Deployment coordination body</td>
<td>The Commission to create a new platform or expand scope of an existing body to lead and coordinate activities on continuity.</td>
</tr>
<tr>
<td></td>
<td>EU-level funding, with requirements on data reporting and exchange as a funding condition.</td>
<td>Set up of shared online platform where data from funded projects is made public by the EU.</td>
</tr>
<tr>
<td></td>
<td>MOUs</td>
<td>Deployment coordination body to track MOUs signed between C-ITS stakeholders, organised at the EU and national level.</td>
</tr>
<tr>
<td></td>
<td>Funding of EU deployment coordination</td>
<td>The Commission to provide funding to deployment coordination body.</td>
</tr>
</tbody>
</table>

**8.3. Evaluation**

While the above section focused on monitoring activities, evaluation of the Delegated Act under Policy Option 2 will be an important component of ensuring that activities performed under the Delegated Act meet the objectives of the act, and perform according to expectations under effectiveness, efficiency, indirect impacts, coherence, and proportionality and subsidiarity criteria. These are the same criteria by which this impact assessment is organised, and as C-ITS is rolled out, the data from deployment projects can help verify and refine future evaluations. For example, while deployment is forecast as part of this study, data from projects can provide data on realised deployment, which can be compared to a number of real world conditions under which that deployment is realised (e.g. funding provided, MOUs signed, number of bodies set up under relevant themes). Another important area where realised data is important will be to supplement the existing literature on the impact of C-ITS services. For this reason, we recommend that any data exchange requirements as part of funding provided include the provision of impact data.

Below we describe proposed criteria for evaluation, organised by key theme for the direct impacts:

- **Privacy and protection of personal data, including access to data and data quality:** Audit findings on GDPR breaches; level of C-ITS user complaints regarding privacy; consumer views (via public consultation); view of consumer protection organisation (via interviews/surveys)
• **Security:** Audit findings on CP/SP breaches; number of bodies/authorities in charge of monitoring security by MS

• **Interoperability:** Breaches of compliance by C-ITS stations for interoperability specifications; Breaches of compliance by C-ITS stations for inability to provide all Day 1 services and Day 1 service profiles; Progress made by standardisation organisations on services beyond Day 1

• **Compliance assessment:** Assessments completed as opposed to assessments required by Directive; Approvals granted to C-ITS stations (by MS and type of station); Approvals not granted to C-ITS stations (by MS and type of station); Number of bodies/authorities set up to oversee compliance assessments (by MS)

• **Continuity:** Activities of the deployment coordination body (meetings, workshops, conferences, papers/guidelines issued), and associated budgetary expenditure (against funding provided by the Commission), plus key performance indicators met by the body

• **Enabling conditions:** C-ITS EU funding spent (by MS, type of service(s), urban/rural, road type(s), countries involved, funding mechanism type); number of C-ITS related MOUs signed

For the indirect impacts, it would be useful to measure:

• Deployment by Member State – km of road network equipped, number of vehicles equipped, personal C-ITS devices equipped, new RSU’s deployed, RSU’s retrofitted, central sub-systems in place (by rural/urban area, road type, service type, long-range versus short-range)

• Costs by Member State – costs incurred by public sector and/or local authorities to procure RSUs, central sub-systems; average price of C-ITS equipped vehicle and costs of maintaining vehicle annually; costs for data usage for C-ITS services; costs for C-ITS applications provided via personal C-ITS devices; other costs not foreseen

• Road safety – accidents involving C-ITS-equipped vehicles and type of accident impact (e.g. fatality, serious injury, light injury, material damage) by in-vehicle and personal C-ITS device, vehicle type, road type, service(s) provided by station, urban/rural, MS, VRU involvement in accident

• Economic impacts – C-ITS-related employment by MS; patents granted on C-ITS; Number of C-ITS providers or related companies by MS

Once real-world C-ITS data has been collected across the EU after deployment begins on a commercial basis, and when the Delegated Act is set for evaluation, the predictions made as part of this study can be compared with realised achievements, exploring the reasons why or why not deployment targets and expected impacts have been met.
9. REFERENCES


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ANNEXES

The annexes have been submitted as separate documents together with the Final report. The list of annexes is shown below.

1. Stakeholder engagement methodology (Annex A)
2. Quantitative modelling methodology (Annex B)
3. Modelling results from two deployment scenarios (Annex C)
4. National and deployment case studies (Annex D)
5. Public Consultation report (Annex E)
6. A list of European C-ITS deployment projects (Annex F)
7. Key model results by Member State (Annex G)
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Annex A – Stakeholder Engagement Methodology
Report for DG MOVE
In November 2012, Ricardo plc acquired the assets and goodwill of AEA Technology plc and formed a new company, Ricardo-AEA Ltd. The entire capability and resources previously represented by AEA Technology plc were transferred to Ricardo-AEA, as were all employees. Consequently, where specific projects or track record referenced in this proposal were undertaken and completed prior to the acquisition, for contractual reasons, these continue to be identified as AEA Technology plc.
A. ANNEX A – STAKEHOLDER ENGAGEMENT METHODOLOGY

A.1 Analysis of responses from the open public consultation

Our feedback on the draft Public Consultation (PC) questions was provided to the Commission following the project kick-off meeting. The PC went live on 10th October 2017 and ran for a period of 13 weeks. It closed on 12th January 2018. The full analysis is detailed in the separate Public Consultation report in Annex E.

A.2 Case studies and interviews

The aim of this task was to produce twelve case studies focussing on C-ITS deployment. Nine case studies are focused on C-ITS deployment projects, which include the following:

- C-Roads deployment projects (Austria, Belgium/Flanders, Czech Republic, France, Germany, Slovenia);
- InterCor;
- NordicWay; and
- C-The Difference.

Three non-EU national C-ITS case studies were also conducted for:

- The US;
- Australia; and
- Japan.

In terms of preparing both the deployment project and national case studies, the study team first undertook a period of desk research, focussing primarily on the introduction to the case studies. The team collated information found on the project websites\(^1\), and other publicly available material to prepare an initial overview of the deployment projects / C-ITS implementation in other selected countries. With regards to the national case studies, the team aimed to update the case studies developed for these countries as part of the previous C-ITS Deployment study.

Following the initial period of desk research, the study team undertook series of telephone interviews with key stakeholders involved in the implementation of deployment projects, or in the relevant implementing organisations within the national case study countries.

Interviews took place between late October 2017 and February 2018. In total, 13 interviews were undertaken with a total of 15 contacts. An overview of the interviews undertaken in preparing the case studies is provided in Table A-1.

Whilst we approached all stakeholder contacts early in the process, including providing a letter of support from the Commission, we were unfortunately unable to arrange interviews with contacts from one case study:

- **InterCor** – Whilst an interview was conducted with the representative for InterCor in the UK, the study team also attempted to arrange an interview with the Netherlands InterCor representative. Two interviews were scheduled with this contact, but they were subsequently unable to attend the calls on both scheduled dates. The study team has continued attempting to arrange further interview dates, but without success.

In addition to the C-ROADS deployment case studies, the study team also undertook an interview with the Secretary General for the C-Roads Platform.

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\(^1\) Both the C-Roads website (https://www.c-roads.eu/platform.html), and the Connecting Europe Facility (CEF) website (https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/cef-transport-projects)
### Table A-1: Stakeholders interviewed to date – Case study Interviews

<table>
<thead>
<tr>
<th>Case type</th>
<th>Study</th>
<th>Case Title</th>
<th>Study</th>
<th>Stakeholder Type</th>
<th>Interview conducted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deployment</td>
<td>C-Roads – Sec Gen of C-Roads programme</td>
<td>Public administration</td>
<td>15th December 2017</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Deployment</td>
<td>C-Roads Austria</td>
<td>Motorway Authority</td>
<td>21st November 2017</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Deployment</td>
<td>C-Roads Czech Republic</td>
<td>C-ITS system/service providers</td>
<td>15th November 2017</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Deployment</td>
<td>C-Roads France</td>
<td>Public administration</td>
<td>31st October 2017</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Deployment</td>
<td>C-Roads Germany</td>
<td>Public administration / Research</td>
<td>23rd November 2017</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Deployment</td>
<td>C-Roads Slovenia</td>
<td>Road and Transport Authorities</td>
<td>10th November 2017</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Deployment</td>
<td>InterCor (C-Roads UK)</td>
<td>Public administration</td>
<td>21st December 2017</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Deployment</td>
<td>NordicWay</td>
<td>Road and Transport Authorities</td>
<td>13th November 2017</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Deployment</td>
<td>C-The Difference</td>
<td>C-ITS system/service providers</td>
<td>24th October 2017</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Deployment</td>
<td>C-Roads Belgium/Flanders</td>
<td>Public administration</td>
<td>23rd February 2018</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>National</td>
<td>Australia</td>
<td>Association (transport and traffic)</td>
<td>20th December 2017</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>National</td>
<td>USA</td>
<td>Public administration</td>
<td>1st November 2017</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>National</td>
<td>Japan</td>
<td>Public administration</td>
<td>13th February 2018</td>
<td></td>
</tr>
</tbody>
</table>

- Deployment | InterCor (C-Roads Netherlands) | Public administration | -
The output for each case study is presented in Annex D to this report following the format set out in Box A-1 and Box A-2.

**Box A-1: Case study format – Deployment project case studies**

1. **Introduction [supported by questions 1 to 3]**
   - Background
   - Objectives

2. **Progress to date [supported by questions 4 and 5]**

3. **Barriers and challenges to feed problem definition [supported by questions 6 to 9]**
   - Continuity of services
   - Security
   - Privacy and protection of personal data
   - Hybrid communication
   - Interoperability
   - Compliance testing
   - Coordination and enabling environment

4. **Views on proposed Delegated Regulation on C-ITS to feed development of policy measures, policy options and monitoring and evaluation framework [supported by questions 10 to 14]**
   - Support measures required:
     - Continuity of services
     - Security
     - Privacy and protection of personal data
     - Hybrid communication
     - Interoperability
     - Compliance testing
     - Coordination and enabling environment
     - Others
   - Monitoring and evaluation

5. **Data collection on cost and performance of different C-ITS services / technologies, to feed into impact assessment modelling [supported by impact table + questions 15 to 19]**
**Box A-2: Case study format – National case studies**

1. **Introduction [supported by questions 1 to 3]**
   - Country:
   - Objectives:
   - Policy approach:
   - Implementing body/ies:
   - Other stakeholders involved:
   - C-ITS technologies that have been/are being deployed:
   - C-ITS services that have been/are being piloted

2. **Progress to date [supported by question 4]**

3. **Barriers and challenges and how these have been overcome [supported by questions 5 to 18]**
   - Approach to, and experience with:
     - Continuity of services
     - Security
     - Privacy and protection of personal data
     - Hybrid communication
     - Interoperability
     - Compliance testing
     - Coordination and enabling environment
     - Others
   - Monitoring and evaluation

4. **Data collection on cost and performance of C-ITS services / technologies (supported by impact table)**

Conclusions have been drawn from the case studies for the problem definition, identification of policy options and impact assessment. Where conclusions have been drawn from specific case studies which have an impact on the outputs from the study they have been directly referenced at the appropriate place in the report.

**A.3 Wider stakeholder consultation**

In addition to the production of case studies, stakeholder engagement has been undertaken to seek validation of the findings of the study focusing on various key themes throughout the study. As outlined in the proposal, this has included interactions with the expert group in order to introduce the group to the study methodology and the progress made on the study at each stage. Six meetings have taken place during the consultation phase of this study, with 3 attended by Ricardo staff.

Further bilateral/multilateral interviews and requests have been carried out beyond the case study interviews and working group meetings where required. On 1st December 2017 the study team reached out to 18 organisations (deployment project contacts as well as

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2 12th October 2017, 8th February 2018 and 13th April 2018
other technical experts) who could contribute specific data for the modelling (cost and input data), or provide commentary around specific issues, e.g. data protection, security, etc. Those who responded are included in Table A-2. Six written responses have been received, furthermore three ad hoc phone discussions were carried out (with Ford, Bosch and 5GAA). A full analysis of the submissions has been carried out and is detailed in Annex B.

**Table A-2: Contacts for data requests – March 2018**

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
<th>Involvement</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harry Ooststroom</td>
<td>RWS</td>
<td>InterCor (NL)</td>
<td>Response received</td>
</tr>
<tr>
<td>Martin Boehm</td>
<td>AustriaTech</td>
<td>C-Roads Platform</td>
<td>Response received</td>
</tr>
<tr>
<td>Matthias Knirsch</td>
<td>Bosch/ CLEPA</td>
<td>ITS Expert</td>
<td>Phone discussion</td>
</tr>
<tr>
<td>Fabian Zacharias</td>
<td>VOLKSWAGEN AG</td>
<td>ITS Expert</td>
<td>Response received</td>
</tr>
<tr>
<td>Onn Haran</td>
<td>Autotalks</td>
<td>ITS Expert</td>
<td>Response received</td>
</tr>
<tr>
<td>Jovan Zagajac</td>
<td>Ford</td>
<td>Manager, Emerging Technologies, Connected Vehicle and Services</td>
<td>Phone discussion</td>
</tr>
<tr>
<td>Tomas Linget</td>
<td>5GAA (Logos, Vodafone, Analysys Mason, Qualcomm, Intel, BMW, Huawei)</td>
<td>ITS experts</td>
<td>Phone discussion</td>
</tr>
</tbody>
</table>

Finally, a stakeholder workshop was held on 9th February 2018, to gather specific information and data and to listen to views and suggestions from experts and stakeholders. The workshop was well attended with more than 140 participants.

In the morning session the project team presented the overview and status of the study and the results of the online public consultation. In the Q&A important elements, including the design of the draft policy options, were discussed. 23 stakeholders presented their views on C-ITS, including among others C-ITS deployment initiatives, car manufacturers, technology and telecommunications providers, organizations representing road users, public transport and cities, and researchers.

The afternoon session consisted of an interactive presentation on the modelling framework for the study, in which the approach and assumptions used in the study were discussed, allowing stakeholders to offer detailed views and help to correct or amend the analytical approach. Some key elements discussed were the cost data and the uptake scenarios in vehicles and infrastructure. The presentations from the consultant and the stakeholders can be found on the Commissions C-ITS webpage.

The discussion in the workshop was complemented by an online survey of attendees to get individual responses on the discussion items. The survey was open for two weeks following the workshop, during which time 19 completed responses were submitted.

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Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Annex B – Quantitative modelling methodology
Report for DG MOVE
In November 2012, Ricardo plc acquired the assets and goodwill of AEA Technology plc and formed a new company, Ricardo-AEA Ltd. The entire capability and resources previously represented by AEA Technology plc were transferred to Ricardo-AEA, as were all employees. Consequently, where specific projects or track record referenced in this proposal were undertaken and completed prior to the acquisition, for contractual reasons, these continue to be identified as AEA Technology plc.
B. ANNEX B: QUANTITATIVE MODELLING METHODOLOGY

B.1 Model methodology

B.1.1 Overview of modelling approach

A series of steps were required to produce the modelling outputs for this study. This involved an extensive data collection exercise (described in more detail in Section B.2.3 and Section B.2.4) and definition of a series of deployment assumptions (described in Section B.2.2, followed by a series of modelling steps centred around the ASTRA and TRUST models, as shown in Figure B-1.

Figure B-1: Key steps in producing CBA modelling outputs

The following figure shows the data flows for the modelling framework, which consists of several sub-models. The first module of the pre-processing is a calculation of penetration rates for vehicles, personal C-ITS devices and infrastructure. These are based on uptake assumptions and stock data. The penetration rates are then combined with impact data in the scenario module. The outputs from the scenario module, percentage improvements across the different policy options and country groupings, are then run through the macro-economic ASTRA/TRUST modelling framework, which will be discussed in more detail in Section B.1.4. The outputs from these two models were then processed and combined into our cost-benefit analysis (CBA) model to produce final outputs. All monetary impacts in this report are presented in present value (2017) terms.
B.1.2 Scenario definition

The model methodology is a matrix-based, ‘building block’ approach for developing policy options, originally agreed with the C-ITS Platform Working Group 1 (WG1) during Phase I of the C-ITS Platform. The main steps of the approach are shown in Figure B-3 below. This matrix approach allows for variation in the scope (in terms of the deployed technology bundles and road/vehicle types) between the different scenarios to be modelled. A further element for differentiating between scenarios are the uptake assumptions for new vehicles, personal ITS devices, and the infrastructure supporting C-ITS services.
B.1.2.1 Step 1 – Definition of relevant service bundles and country grouping

**Country Grouping**

Countries are being grouped by C-ITS deployment activities for the initial phases of the modelling. This helps to reduce the level of disaggregation for the C-ITS specific modelling inputs and allows for a structured analysis of impacts on front-runners/follower countries, which is easier to comprehend than an analysis on the Member State level. This also allows for a structured analysis of the impacts of deployment on each country grouping, which is easier to review than at the Member State level. Once the input data is run through the macro-economic models, modelling results for each Member State will be obtained and presented at a disaggregated level.

The methodology for the country grouping of Member States considers the number of C-ITS deployment projects and the share of TEN-T corridor/core network equipped, which has been identified from a comprehensive analysis of existing and forthcoming C-ITS deployment projects across Europe. The full list of European projects considered in this study is presented in Annex F. Using this information, EU Member States were grouped into three categories: ‘Front Runner’, ‘Planned Adopter’, or ‘Follower’. The country groupings are an indicator of ambition in the field of C-ITS and consider the actual and planned scale of deployment across the road network in each Member State.

Member States were ranked based on the number of C-ITS deployment projects and network length equipped. Countries that were in the top ten for both criteria were assigned as Front Runners. Countries that have 0% of TEN-T corridor/core network equipped were assigned as Followers, and the remaining countries were assigned as Planned Adopters. The final list of country groupings is displayed in Figure B-2.

The average network lengths equipped was calculated for each country grouping, which are used as the average penetration rates for infrastructure for each country grouping in the baseline. The value was calculated as a weighted average of the network length equipped of each Member State in the respective grouping. The weighting was based on vehicle activity in each Member State.
A weighting between the infrastructure type (short-range or cellular communications) was calculated based on the communication technology employed in each deployment project. A count was made on the number of deployment projects in each member state that were associated with short range, cellular or both technologies. The Member State count was aggregated for each country grouping and we then calculated a ratio between the two technologies. In line with a policy of technology neutrality, which has been favoured by the majority of deployment projects described in our case studies, the calculation indicated a 50:50 weighting between the two technologies for Front Runners, who have made the most progress. Consequently, this weighting has been adopted for other country groups as we expect they will eventually match the activity of Front Runners in the split of infrastructure type.

Table B-1: Country grouping by project and road equipped %

<table>
<thead>
<tr>
<th>Country</th>
<th>Projects with deployment (non-urban; project type: deployment, FOT, pilot project)</th>
<th>Equipped TEN-T Core + Corridor Road Length / Network TEN-T Road Length</th>
<th>Categorisation</th>
<th>Weighted average TEN-T Core + Corridor road length equipped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>5</td>
<td>33%</td>
<td>Front Runner</td>
<td>26.12%</td>
</tr>
<tr>
<td>Finland</td>
<td>6</td>
<td>20%</td>
<td>Front Runner</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>14</td>
<td>38%</td>
<td>Front Runner</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>12</td>
<td>18%</td>
<td>Front Runner</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>12</td>
<td>29%</td>
<td>Front Runner</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>5</td>
<td>34%</td>
<td>Front Runner</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>1</td>
<td>80%</td>
<td>Planned Adopter</td>
<td>11.80%</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>4</td>
<td>24%</td>
<td>Planned Adopter</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>3</td>
<td>9%</td>
<td>Planned Adopter</td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>6</td>
<td>2%</td>
<td>Planned Adopter</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>7</td>
<td>8%</td>
<td>Planned Adopter</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>3</td>
<td>2%</td>
<td>Planned Adopter</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>1</td>
<td>22%</td>
<td>Planned Adopter</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>14</td>
<td>4%</td>
<td>Planned Adopter</td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>8</td>
<td>7%</td>
<td>Planned Adopter</td>
<td></td>
</tr>
<tr>
<td>Bulgaria</td>
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<td>0%</td>
<td>Follower</td>
<td>0%</td>
</tr>
<tr>
<td>Croatia</td>
<td>0</td>
<td>0%</td>
<td>Follower</td>
<td></td>
</tr>
<tr>
<td>Cyprus</td>
<td>0</td>
<td>0%</td>
<td>Follower</td>
<td></td>
</tr>
<tr>
<td>Estonia</td>
<td>0</td>
<td>0%</td>
<td>Follower</td>
<td></td>
</tr>
<tr>
<td>Hungary</td>
<td>0</td>
<td>0%</td>
<td>Follower</td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>0</td>
<td>0%</td>
<td>Follower</td>
<td></td>
</tr>
<tr>
<td>Latvia</td>
<td>0</td>
<td>0%</td>
<td>Follower</td>
<td></td>
</tr>
<tr>
<td>Lithuania</td>
<td>0</td>
<td>0%</td>
<td>Follower</td>
<td></td>
</tr>
<tr>
<td>Luxembourg</td>
<td>1</td>
<td>0%</td>
<td>Follower</td>
<td></td>
</tr>
<tr>
<td>Malta</td>
<td>0</td>
<td>0%</td>
<td>Follower</td>
<td></td>
</tr>
</tbody>
</table>
Service bundle definition

For the purposes of the modelling, C-ITS services have been grouped into a series of service bundles, based on several metrics, including: whether they are V2V, V2I or V2X; whether they are Day 1 or Day 1.5 services; their primary targeted geographic deployment areas (motorways, urban); and their primary purpose. The process for developing these service bundles was heavily informed by an extensive literature review and consultation with WG1 members during Phase I of the C-ITS platform. The list has been aligned with the list of priority C-ITS services of the Commission’s C-ITS Strategy\(^1\). The final set of service bundles are described in Table B-2 below.

Through our matrix approach (see Section B.1.2.2) the applicability of the different service bundles for deployment on different types of roads and different types of vehicles will be considered and varied through the individual scenarios considered.

---

### Table B-2: C-ITS service bundles for scenario building

<table>
<thead>
<tr>
<th>Service bundle</th>
<th>C-ITS Services</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bundle 1</strong>&lt;br&gt;Day 1, V2V</td>
<td>• Emergency brake light.&lt;br&gt;• Emergency vehicle approaching.&lt;br&gt;• Slow or stationary vehicle(s).&lt;br&gt;• Traffic jam ahead warning.&lt;br&gt;• Hazardous location notification.</td>
<td>• Day 1 safety-based V2V services(^2). Applicable to all road types but benefits are most likely to be delivered on motorways.</td>
</tr>
<tr>
<td><strong>Bundle 2</strong>&lt;br&gt;Day 1, V2I, mainly applicable to motorways</td>
<td>• In-vehicle signage.&lt;br&gt;• In-vehicle speed limits.&lt;br&gt;• Probe vehicle data.&lt;br&gt;• Shockwave damping.&lt;br&gt;• Road works warning.&lt;br&gt;• Weather conditions.</td>
<td>• Day 1 V2I services that deliver most benefit to motorways. Some services listed here may also be applicable to other road types.</td>
</tr>
<tr>
<td><strong>Bundle 3</strong>&lt;br&gt;Day 1, V2I, mainly applicable to urban areas</td>
<td>• Green Light Optimal Speed Advisory (GLOSA) / Time To Green (TTG).&lt;br&gt;• Signal violation/Intersection safety.&lt;br&gt;• Traffic signal priority request by designated vehicles.</td>
<td>• Day 1 V2I services that are expected to only be applicable in urban areas. Therefore, these services are in a separate bundle to those in Bundle 2.</td>
</tr>
<tr>
<td><strong>Bundle 4</strong>&lt;br&gt;Day 1.5, V2I, Parking Information</td>
<td>• Off street parking information&lt;br&gt;• On street parking management and information.&lt;br&gt;• Park &amp; Ride information.&lt;br&gt;• Information on AFV fuelling &amp; charging stations.</td>
<td>• C-ITS services intended to provide information regarding parking (and refuelling) to drivers.</td>
</tr>
<tr>
<td><strong>Bundle 5</strong>&lt;br&gt;Day 1.5, V2I, Traffic and other information</td>
<td>• Traffic information and smart routing.</td>
<td>• C-ITS services intended to provide traffic information to drivers.</td>
</tr>
<tr>
<td><strong>Bundle 7</strong>&lt;br&gt;Day 1.5, V2X, mainly applicable to urban areas</td>
<td>• Vulnerable road user protection (pedestrians and cyclists).</td>
<td>• V2X service expected to be post Day 1. Main benefits are likely to be seen in urban areas.</td>
</tr>
</tbody>
</table>

Note: The list of services for this project is slightly reduced compared to the services considered for the 2016 C-ITS Deployment study, to ensure consistency with the EU C-ITS Strategy, however, the numbering of the bundles has been retained.

#### B.1.2.2 Step 2 - Defining a matrix of priority scenario building blocks

Having defined a series of relevant service bundles, the likely applicability of each bundle to the different road geographies and vehicle types was next considered. The applicability of each service bundle has been determined by their technical compatibility, the likely magnitude of benefits associated with each service bundle/road geography/vehicle type

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\(^2\) Currently subject of a proposed rule-making concerning a V2V mandate in the US, which may result in more widespread deployment of these type of services
combination, and the likelihood of achieving significant long-term penetration in that segment. Based on this thought process, the applicability of each service bundle to different combinations of road geography and vehicle type can be represented in a colour-coded matrix to visually represent the most applicable combinations, as shown in Figure B-4 below.

Each service bundle/road geography/vehicle type combination can be thought of as a basic building block, from which scenarios can be developed by deploying each building block at different times and rates. The most applicable combinations from the colour-coded matrix (i.e. those in dark green) represent the most relevant building blocks from which scenarios can be built initially.

**Figure B-4: Mapping of applicability of service bundles to different road geographies and vehicle types**

<table>
<thead>
<tr>
<th>Bundle of services</th>
<th>TEN-T Core</th>
<th>TEN-T Core</th>
<th>Other Motorways</th>
<th>Other Interurban Roads</th>
<th>Urban</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bundle 1</td>
<td>V</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
<td>Emergency brake light</td>
</tr>
<tr>
<td>Day 1 V2V - safety</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Emergency vehicle approaching slow or stationary vehicle(s)</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Traffic jam ahead warning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hazardous location notification</td>
</tr>
<tr>
<td>Bundle 2</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td>Road works warning</td>
</tr>
<tr>
<td>Day 1 V2I (mainly applicable to motorways)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Weather conditions</td>
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<td></td>
<td></td>
<td>In-vehicle signage</td>
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<td></td>
<td></td>
<td></td>
<td>In-vehicle speed limits</td>
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<td></td>
<td></td>
<td></td>
<td>Probe vehicle data</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Shockwave damping</td>
</tr>
<tr>
<td>Bundle 3</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td>GLOSA/TTG</td>
</tr>
<tr>
<td>Day 1 V2I (mainly applicable to urban areas)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Signal violation/intersection safety</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Traffic signal priority request by designated vehicles</td>
</tr>
<tr>
<td>Bundle 4</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td>On street parking information</td>
</tr>
<tr>
<td>Day 1.5 V2I - Parking information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>On street parking management and information</td>
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<td></td>
<td>Park &amp; Ride information</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Information on fuelling &amp; charging stations for AFVs</td>
</tr>
<tr>
<td>Bundle 5</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td>Traffic information &amp; smart routing</td>
</tr>
<tr>
<td>Day 1.5 V2I - Traffic information</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Bundle 7</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Vulnerable road user protection</td>
</tr>
<tr>
<td>Day 1.5 - V2X (mainly applicable to urban areas)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colour coding key:</td>
<td>Highly applicable</td>
<td>Applicable</td>
<td>Applicable but limited benefits</td>
<td>Few benefits</td>
<td>Not relevant in this environment</td>
<td></td>
</tr>
</tbody>
</table>

**B.1.2.3 Step 3 - Building independent scenarios**

By selecting various combinations of the most relevant building blocks and combining these with variations in the uptake rate assumptions, a series of scenarios can be developed, with each scenario exhibiting increased scope (based on the matrix approach) or uptake rate (based on underlying uptake assumptions) for in-vehicle C-ITS sub-systems and roadside C-ITS sub-systems.

For the baseline scenario the matrix setting out the scope of deployment regarding road types, C-ITS services and vehicle types is shown below (Figure B-5). These scope assumptions influence where impacts of services of the different bundles will materialise. For the different policy options the scope of services (in terms of bundles, vehicle types...
and road types) does increase. The assumptions on scope resulting from the individual matrices are then further combined with uptake rates as discussed in Section B.2.2.

**Figure B-5: Matrix for baseline scenario**

<table>
<thead>
<tr>
<th>Bundle of services</th>
<th>TEN-T Corridors</th>
<th>TEN-T Core</th>
<th>Other Motorways</th>
<th>Other Interurban Roads</th>
<th>Urban</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bundle 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1 V2V - safety</td>
<td>V</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Emergency brake light</td>
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<td></td>
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<td></td>
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<td></td>
<td>Emergency vehicle approaching</td>
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<td></td>
<td>Slow or stationary vehicle(s)</td>
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<td>Traffic jam ahead warning</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hazardous location notification</td>
</tr>
<tr>
<td><strong>Bundle 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1 V2V (mainly applicable to motorways)</td>
<td>I</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Road works warning</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Weather conditions</td>
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<td></td>
<td>In-vehicle signage</td>
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<td></td>
<td>In-vehicle speed limits</td>
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<td>Probe vehicle data</td>
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<td>Shockwave damping</td>
</tr>
<tr>
<td><strong>Bundle 3</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1 V2V (mainly applicable to urban areas)</td>
<td>I</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>GLOSA/TTG signal violation/intersection safety</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Traffic signal priority request by designated vehicles</td>
</tr>
<tr>
<td><strong>Bundle 4</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1.5 V2I - Parking information</td>
<td>I</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Off street parking information</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>On street parking management and information</td>
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<td></td>
<td>Park &amp; Ride information</td>
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<td></td>
<td></td>
<td></td>
<td>Information on fuelling &amp; charging stations for AFVs</td>
</tr>
<tr>
<td><strong>Bundle 5</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Day 1.5 V2I - Traffic information</td>
<td>I</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Traffic information &amp; smart routing</td>
</tr>
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<td></td>
</tr>
<tr>
<td><strong>Bundle 7</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1.5 - V2X (mainly applicable to urban areas)</td>
<td>X</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Vulnerable road user protection</td>
</tr>
</tbody>
</table>

**Colour coding key:**

- Highly applicable
- Applicable
- Applicable but limited benefits
- Few benefits
- Not relevant in this environment

In Policy Option 1, 2 and 3 the scope is extended to cover Day 1 services across all applicable vehicle and road type combinations (see Figure B-6). Variation between the Policy Options come in through the different uptake rates as presented in Section B.2.2.
B.1.3 Pre-processing of data to calculate impacts

B.1.3.1 Penetration rate estimates

Penetration rate estimates are made in the penetration calculation module of the modelling framework as shown in Figure B-2 in Section B.1.1.

Uptake rates are used to estimate the penetration of C-ITS services into the total vehicle fleet, through new vehicles and personal ITS sub-systems (smartphones). Different uptake rates across cars, trucks and buses are considered. Total annual vehicle fleet size and annual vehicle sales for EU28 countries were provided by TRT from their ASTRA model run for the baseline scenario as well as EUROSTAT data for 2015. In the ASTRA model, car stock is modelled as well as new cars entering the fleet each year. Both stock and new vehicles are segmented by fuel, Euro standard and vehicle age. Penetration rates of C-ITS services can be consistently applied on new or existing vehicles by vehicle age as the size of vehicle fleet stock and annual sales are not affected by the assumptions on C-ITS. In fact, the development of the car fleet in the ASTRA model does not depend on the penetration of C-ITS solutions nor C-ITS services equipment is included among the characteristics of vehicle fleet segmentation in the ASTRA model. These input uptake assumptions (in terms of percentage penetration of the fleet) are unaffected by the ASTRA/TRUST modelling but the resulting impacts (in terms of percentage change) are combined in ASTRA/TRUST with the actual activity/fleet for each Member State.
Similarly, uptake rates are used to estimate the extent of roads equipped with C-ITS supporting infrastructure. Separate rates are defined for C-ITS that is delivered through cellular and ITS-G5 (RSU) technologies. Different uptake rates for TEN-T Core, TEN-T Corridor, other motorways and other inter-urban roads are also considered. Total network road length by road type was provided by TRT based on the TRUST model road network for the EU28 countries.

The detailed uptake assumptions can be found in Section B.2.2 Uptake and penetration rates in the baseline and policy options.

**B.1.3.2 Scenario model**

The penetration rates obtained from the penetration calculation module are further processed in the scenario model, which combines uptake with impacts for different C-ITS services, covering:

- Reductions in fuel consumption
- Reductions in polluting emissions
- Reduction of accident rates
- Increase in average speed

The full list of impact inputs considered in the model is presented in Section B.2.3 C-ITS service impact data.

Since a number of C-ITS services covered in this study have similar functionality, multiple services are likely to overlap and be applicable to the same driving scenarios. The approach for accounting for the overlap between services in order to avoid double-counting impacts is described in Section B.2.3.5 Overlap between services.

For each policy option and country grouping combination the module calculates the percentage improvements over time. This information is then further processed in the ASTRA/TRUST modelling framework.

**B.1.4 ASTRA and TRUST modelling**

ASTRA is a strategic model based on the Systems Dynamics Modelling approach, which simulates the EU transport system in combination with the economy and the environment. It is calibrated to reproduce major indicators such as fuel consumption, CO₂ emissions and GDP. On the other hand, TRUST is a European transport network model that can compute energy consumption, pollutant emissions and accidents by road classification (TEN-T Corridors, Core TEN-T etc.). The following sections provide details of the two models.

**B.1.4.1 ASTRA model**

ASTRA is a strategic model based on the Systems Dynamics Modelling approach simulating the transport system in combination with the economy and the environment. The model is made of different modules that are linked to each other.

As illustrated in Figure B-7, ASTRA consists of different modules, each related to one specific aspect such as the economy, transport demand or the vehicle fleet. The main modules cover the following aspects:

- Population and social structure (age cohorts and income groups)
- Economy (including input-output tables, government, employment, consumption and investment)
- Foreign trade (inside EU and to partners from outside EU)
- Transport (including demand estimation, modal split, transport cost and infrastructure networks)
- Vehicle fleet (passenger and freight road vehicles)
Environment (including pollutant emissions, CO₂ emissions, fuel consumption).

Geographically, ASTRA covers all EU 28 Member States³ plus Norway and Switzerland.

**Figure B-7: Overview of linkages between the modules in ASTRA**

The macro-economic module simulates the fundamental economic variables. Some of these variables (e.g. GDP) are transferred to the transport generation module, which uses the input to generate a distributed transport demand. In the transport module, transport demand is split by mode of transport. The traffic performance by mode is associated with the composition of the fleet (computed in the vehicle fleet module) and the emissions factors (defined in the environmental module), in order to estimate total emissions.

Several feedback effects take place in the model. For instance, the economic module provides the level of income to the fleet module, in order to estimate vehicle purchase. The economic module then receives information on the total number of purchased vehicles from the fleet module to account for this item of transport consumption and investment. Furthermore, changes in the economic system immediately feed into changes of the transport behaviour and alter origins, destinations and volumes of European transport flows.

The treatment of the linkage between transport and the economy is particularly detailed due to some 'micro-macro bridges'. For instance, transport expenditures in the transport module produce changes in sectoral consumption and GDP at the national level: closing the feedback loop therefore implies to establish either macro-micro bridges (e.g. from GDP and sectoral output to goods flows) or vice versa micro-macro bridges (e.g. from transport investments into vehicle fleets to overall investments). This is important in this study, as ASTRA allows us to carry out analysis of the macro-economic impacts of the proposed policy options.

The main micro-macro bridges link:

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³ Croatia has recently been added to the model.
- Passenger transport and sectoral consumption
- Transport and sectoral investment
- Transport and sectoral employment
- Freight transport and total factor productivity
- Transport and intermediate inputs of input-output tables
- Transport and exports.

In addition, government revenues and expenditures are differentiated as far as possible into categories that can be modelled endogenously by ASTRA and one category covering other revenues or other expenditures. Categories that are endogenous comprise, for example, VAT and fuel tax revenues, revenues from transport charges, and transport investments. Intermediate demand is modelled by means of an explicit Input-Output mechanism that describes the technical coefficients between the economic sectors.

The environment module uses input from the transport module (in terms of vehicle-kilometres-travelled per mode and geographical context) and from the vehicle fleet module (in terms of the technical composition of vehicle fleets), in order to compute fuel consumption, greenhouse gas emissions and air pollutant emissions from transport. ASTRA also estimates the upstream emissions (well-to-tank) due to fuel production and vehicles production. Therefore, well-to-wheel emissions can be provided as well.

In terms of road transport time, ASTRA simulates the impacts of traffic and/or infrastructure network in a simplified way. In fact, the effect of speed-flow functions is included in the model indirectly: in other words, the increase of traffic flow has an impact on transport time but the functions and capacity values are not implemented directly in the tool. The road network is differentiated into three “categories”: Urban, Non-Urban – short distance, Non-Urban - long distance. For each category, the impact of speed-flow functions is simulated separately.

ASTRA is calibrated to reproduce major indicators such as transport performance, fuel consumption, CO₂ emissions and GDP according to the main European reference sources such as Eurostat until 2015 and the EU Reference Scenario (European Commission, 2016) for future trends.

More details on the ASTRA model and its applications can be found at the ASTRA website: http://www.astra-model.eu/.

**Recent developments**

Compared to the version of ASTRA used in the 2016 C-ITS deployment project, the current version includes two recent developments.

First, the model has been expanded in terms of geographical coverage to now cover Croatia.

Second, the simulation of the impacts of TEN-T projects in terms of time and cost variations is improved and directly linked to the TRUST network model results (where the physical changes are implemented in the road and rail network), taking into account different demand segments and geographical dimensions.

Finally, the model has been recalibrated to reproduce observed statistics of transport activity, energy consumption, accidents in past years and to follow projections of the EU Reference scenario 2016 (European Commission, 2016) for future years.

More in details, in the baseline scenario developed for this study observed statistics have been used for the year 2015 (where available), and the trends simulated with the ASTRA model have been applied to estimate the evolution over time until 2035.
In the baseline scenario the ASTRA model estimates that in EU28 countries passenger transport activity (in terms of pkm) will grow as much as 24% between year 2015 and year 2035 (1.1% per year). At the same time, freight transport activity for road and rail modes (in terms of tkm) is estimated to increase by 39% between 2015 and 2035 (1.66% per year), with road transport (HDV and LDV) increasing by 37.5% (1.7% per year).

With reference to road safety, the ASTRA model covers the following categories of accidents: fatalities, serious injuries, and slight injuries. The estimation is endogenously performed for cars (and vans), buses, HDV and LDV, while exogenous parameters are applied to estimate accidents related to motorized 2-wheelers, cyclists and pedestrians.

The trend of road accidents over the 2015-2035 period in the reference scenario of the ASTRA model is aligned to the EC baseline scenario provided by the Commission. On top of the reference scenario, some C-ITS impacts are expected in the baseline scenario of this study. This is generally the case for all baseline impacts, but the additional impacts of C-ITS in the baseline compared to the reference scenario are particularly important.

In the year 2015, the annual number of fatalities, serious and slight injuries in EU28 countries for motorised road modes is about 1,051,000 accidents. According to the ASTRA baseline projections, the number of total accidents is expected to decrease by 11.3% by 2035 relative to 2015, i.e. about 932,000 accidents in 2035. The decrease is different according to the seriousness of the accidents: the number of fatalities would decrease by 17.9%, while the reduction in the serious and slight injuries would be lower at 11.3% and 11.2%. Adding in the analysis also non-motorised modes (cyclists and pedestrians), the number of total accidents is about 1,460,400 in 2015, projected to decrease to 1,294,200 in 2035 (by 11.4%).

In terms of energy consumption, according to the ASTRA baseline, the road transport modes are expected to decrease their energy use by 9.3% by 2035 (-0.5% per year), relative to 2015. As a consequence, tank-to-wheel annual CO₂ emissions from road transport would fall by 15% by 2035 relative to 2015 (-0.8% per year). Reduction of CO₂ emissions is larger than reduction of energy consumption because of a different energy mix, with larger shares of low-carbon fuels.

With reference to road safety, the ASTRA model covers the following categories of accidents: fatalities, serious injuries, and slight injuries. The estimation is endogenously performed for cars, vans, buses and heavy goods vehicles, while exogenous parameters are applied to estimate accidents related to motorized 2-wheelers, cyclists and pedestrians.

In terms of air pollutant emissions, the ASTRA model estimates the impacts on VOC, NOx and PM. According to the ASTRA baseline projections, the pollutant emissions are expected to decrease until the year 2035 on an annual basis respectively by 2.4% for PM, 4.5% for Nox and 1.3% for VOC.

### B.1.4.2 TRUST model

TRUST (TRansport eUropean Simulation Tool) is a transport network model developed by TRT in the VISUM software environment for the assignment of Origin-Destination matrices at the NUTS3 level of detail for passenger and freight demand.

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4 P2W, car, bus, HDV and LDV  
5 Fatalities, serious and slight injuries  
6 Car, bus, HDV and LDV  
7 The baseline scenario developed for this impact assessment does not reflect the recent initiatives proposed by the Commission that have a direct impact on CO₂ emissions (e.g. CO₂ standards for new light duty vehicles for 2030, CO₂ standards for heavy goods vehicles for 2030, revision of the Clean Vehicles Directive, etc.)
The matrices of tonnes and passengers are estimated from various sources, including Eurostat, national statistics and ETIS. Intra-NUTS3 demand is not part of the matrices as it is not assigned to the network, but implicitly considered as pre-load on links.

The model is calibrated to reproduce tonnes-km and passengers-km by country consistent to the statistics reported in the Eurostat Transport in Figures pocketbook (net of intra-NUTS3 demand, which is not assigned to the network). At Member State level, the trend of road transport activity has been aligned to the trend of road transport demand in the ASTRA model.

All of Europe is covered, including Accession and Neighbouring countries. A less detailed zoning system is used for other European countries (e.g. European Russia, Ukraine).

The TRUST road network includes all the relevant links between the NUTS3 regions, i.e. motorways, primary roads as well as roads of regional and sub-regional interest. Also ferry connections (Ro-Ro services) between European regions and between European regions and the North Africa are explicitly modelled with their travel time and fare. Road network links are separated in different classes, each with specific features in term of capacity, free-flow speed and toll. The link types distinguish different road categories (e.g. motorways). Within the same category link types distinguish roads with other different features, in particular toll level. Specific flags are used to identify links belonging to the Core TEN-T Network, to each TEN-T corridor and to the Comprehensive network.

Matrices are in terms of trips or tonnes in an average day (24 hours). Trips and tonnes are endogenously translated into vehicles loaded onto the road network by means of average occupancy and load factors.

Table B-3: Occupancy / Load factors in the TRUST road model

<table>
<thead>
<tr>
<th>Demand segment</th>
<th>Occupancy factor / Load factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Passenger</strong></td>
<td></td>
</tr>
<tr>
<td>Short distance (&lt; 100 km) commuting</td>
<td>1.5 pers/veh</td>
</tr>
<tr>
<td>Short distance (&lt; 100 km) non-commuting</td>
<td>1.8 pers/veh</td>
</tr>
<tr>
<td>Long distance (&gt; 100 km)</td>
<td>1.9 pers/veh</td>
</tr>
<tr>
<td><strong>Freight</strong></td>
<td></td>
</tr>
<tr>
<td>Domestic Short distance (&lt;= 50 km)</td>
<td>4 t/veh (empty trips are considered)</td>
</tr>
<tr>
<td>Domestic average distance (50 – 150 km)</td>
<td>10 t/veh (empty trips are considered)</td>
</tr>
<tr>
<td>Domestic Long distance (&gt;= 150 km)</td>
<td>10 t/veh (empty trips are considered)</td>
</tr>
<tr>
<td>International</td>
<td>14 t/veh (empty trips are considered)</td>
</tr>
</tbody>
</table>

Source: TRT, TRUST model

For each Origin/Destination pair, the model distributes demand among available alternative routes using a logit algorithm. The utility of each path is measured in terms of generalised cost i.e. the sum of monetary costs and monetary equivalent of travel time. Travel time on each link of the road network depends on link features and on the level of congestion through specific speed-flow functions. Travel cost depends on link-based tolls and on cost parameters representing the variable operating costs (fuel and, for trucks,

\[^8\] Value of Time parameter is estimated by mode (car or truck), distance band (short, long) and country based on HEATCO D5, Developing Harmonised European Approaches for Transport Costing and Project Assessment (2006)
driver costs) relevant for path choice. Variable operating costs are different across freight demand segments to reflect that lighter vehicles are used on short distances rather than on long distances. In addition, values of travel time, used to compute the generalised cost, are different among the freight demand segments.

The main output of the model is the load on network links in terms of vehicles per day (see example below, Figure B-8).

Using traffic load as an input parameter, the model also provides emissions by link for VOC, NOx, CO, PM and CO₂. Emissions factors based on COPERT functions and on the average fleet composition are used in the model to estimate total emissions. When the model is run for forecasting purposes for future years, the emission factors are updated considering the ASTRA projections regarding the evolution of the fleet in the selected year.

Accidents are estimated based on traffic load by link with the application of accident rates.

**Figure B-8: TRUST model link flows**

![TRUST model link flows](image)

*Source: TRUST model*

**Recent developments**

The TRUST underwent two main revisions since 2016. First, the classification of roads has been updated. In particular, the identification of the TEN-T comprehensive network has
been improved and made fully consistent to the official TENtec classification\(^9\). Second, the model has been re-calibrated for the future years in order to be consistent with the projections of the EU Reference Scenario (European Commission, 2016).

**B.1.4.3 Application of the modelling tools**

In carrying out the modelling analysis, the different scenarios are translated into specific inputs for the two models.

The **ASTRA model** is used to produce indicators at the national level, including e.g.: mode split, transport energy demand, CO\(_2\) emissions, pollutant emissions (VOC, NOx and PM), road accidents, average individual expenditure for mobility, macro-economic impact on GDP. ASTRA is run on an annual basis until the year 2035: the impacts of each scenario are observed over time in terms of aggregated indicators.

The **TRUST network model** is used to produce indicators by mode (cars and trucks) based on road network links, such as fuel consumption, CO\(_2\) emissions, pollutant emissions (NOx, VOC and PM) and accidents. Four different categories of road network are considered: TEN-T Corridors, Rest of TEN-T Core network, TEN-T comprehensive, other interurban roads. TEN-T comprehensive roads are considered representative of ‘other motorways’, which is the designation used in this study. The TRUST model is run every five years from 2015 to 2035, simulating the relevant changes on the supply side (evolution of road network over time due to the completion of TEN-T core and non-core network) and on the demand side (i.e. updated origin-destination matrix). The matrix update is based on the growth rates of demand by mode, country, Origin-Destination and spatial domain provided by ASTRA.

**Figure B-9: Use of the modelling tools for scenarios simulation**

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**B.1.5 Cost Benefit Analysis**

Three main data inputs are required to carry out the Cost Benefit Analysis of the various policy options developed, namely:

- C-ITS service and infrastructure uptake and penetration rates:
  - Vehicle penetration/uptake rates allow an estimation to the total number of vehicles within the vehicle fleet for each vehicle category (or amongst new vehicles) equipped with the technologies required to support C-ITS services.

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Separate penetration rates are also necessary to represent the extent of different road types equipped with C-ITS supporting infrastructure, allowing them to offer Vehicle-to-Infrastructure (V2I) services.

The full list of uptake/penetration assumptions are summarised in Section B.2.2 Uptake and penetration rates in the baseline and policy options.

C-ITS service impact data:
- These are the impacts of C-ITS services on individual vehicles when installed across different vehicle and road types.
- Impacts can be in terms of reduced congestion/average journey speed, fuel consumption, CO₂ emissions, polluting emissions, or accident rates.
- Individual impacts are combined with C-ITS deployment scenario service bundle uptake and penetration rates in the ASTRA/TRUST modelling environments to estimate the total EU-level impact of services for each deployment scenario.
- The EU-level impacts are converted to monetised benefits using typical values for the external cost of transport from the Handbook on External Costs of Transport (Ricardo-AEA et al., 2014).
- The full list of C-ITS service impact data inputs and assumptions are summarised in Section B.2.3 C-ITS service impact data.

C-ITS supporting technology and service costs:
- Cost data makes up the final main input element for the CBA, allowing the uptake and penetration rates for different services to be translated into costs, in order to compare them directly to the estimated benefits from the various EU-level impacts calculated from the modelling.
- The full list of cost data inputs and assumptions are summarised in Section B.2.4 C-ITS technology and service costs.

B.2 Model inputs / assumptions

B.2.1 Methodology for data collection

B.2.1.1 Literature review
The impacts and cost data collection exercise built on our extensive literature review of over 150 documents covering various aspects of C-ITS services and related technologies. A list of the main sources which contributed to the analysis is included in the main report, with the key sources contributing to each of the data input categories described listed in Section B.2.3 C-ITS service impact data and Section B.2.4 C-ITS technology and service costs.

Where the modelling input data was not directly available from literature, a number of approaches were used to fill the data gaps, including:
- Identifying costs or impacts from other non-C-ITS services or technologies which are expected to operate through a similar mechanism to specific C-ITS services.
- Estimating costs or impacts. For example, using known accident data linked to specific accident types targeted by certain C-ITS services to estimate the impact of a specific C-ITS service on accident rates.

B.2.1.2 Expert input
Whilst the main source of input data for the costs and impacts data was the extensive literature review described above, the uptake and penetration rates used to define each policy option were defined through discussions with the Commission services and
stakeholders at the workshop on 9th February 2018. These also built upon previous stakeholder discussions as part of the 2016 Deployment Study.

Cost and impact data were verified by experts through data requests, as discussed in Annex A.

**B.2.2 Uptake and penetration rates in the baseline and policy options**

**B.2.2.1 Introduction**

Following on from the baseline measures we have made assumptions that are needed to translate the measures into uptake in the baseline. These are organised to present uptake for (i) in-vehicle C-ITS stations (using hybrid communication) in new vehicles, (ii) personal ITS devices in existing vehicles that are not equipped with in-vehicle C-ITS stations, and (iii) infrastructure uptake.

The deployment rates under the baseline have been established through an iterative process that began by considering the baseline used in the 2016 C-ITS deployment study (Ricardo, 2016), which was the result of significant expert input from the C-ITS Platform Working Group. These rates were further developed based on expert judgement from the Ricardo team and the Commission, comparison against available literature and finally verification at the stakeholder workshop held in Brussels in February 2018.

The duration of C-ITS uptake into new vehicles has been reflected by the number of vehicle full-model and facelift cycles, as it is through these updates that C-ITS technology will enter the vehicle fleet. Full model cycles involve vehicle redesigns. Personal transport vehicles are assumed to have full model cycles of 7 years while public service vehicles (buses) and freight vehicles are assumed to have longer cycles of 9 years. These model lifecycles were presented and validated at the stakeholder workshop. Facelift cycles occur between full-model redesigns and comprise minor upgrades to vehicle functionality and styling that occur midway through a model’s lifecycle to keep market interest in the vehicle high. Personal transport vehicles are assumed to have facelift cycles of 4 years and public & freight transport are assumed to have longer facelift cycles of 5 years.

**B.2.2.2 Uptake of C-ITS services in new vehicles**

**B.2.2.2.1 Baseline**

In new vehicles, baseline uptake is defined for C-ITS bundles 1, 2, and 3, which are all Day 1 services. Table B-4 presents the baseline uptake assumptions for new vehicles.

**Table B-4: Baseline - uptake assumptions for ITS sub-systems in new vehicles**

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Bundle 1</th>
<th>Bundle 2</th>
<th>Bundle 3</th>
<th>Bundles 4, 5, 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Transport</td>
<td>Uptake across all car categories reaches 100% in 5 vehicle full model cycles (5x7 years = 35 years) starting in 2019.(^{11})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Transport</td>
<td>No Uptake</td>
<td></td>
<td>Uptake also reaches 100% in 5 full model cycles starting 2019, but over 45 years (5x9 years) to reflect different model cycles.</td>
<td>No Uptake</td>
</tr>
</tbody>
</table>

\(^{10}\) Assumed value substantiated by analysis of the generation model cycles of 16 personal vehicles (4 from each car category: A/B,C,D,E/F). Values of 7 years for cars and 9 years for freight were agreed as reasonable by stakeholders at the workshop.

\(^{11}\) This assumption is consistent with work for the RISM/GSPR baseline assuming Medium uptake with 40% voluntary propagation within the fleet without additional stimuli over the course of 14 years.
Key assumptions and inputs

- The baseline was developed together with stakeholders at the workshop in February 2018. The final baseline aligns with baseline used in the 2016 C-ITS deployment study (Ricardo, 2016) which was developed together with technical experts in working groups under the C-ITS platform.

- The uptake start year (2019) is based on the Memorandum of Understanding between the CAR 2 CAR Communication Consortium and the C-Roads Platform, which aims for initial C-ITS deployment across Europe by 2019\(^\text{12}\) (CAR 2 CAR Communication Consortium & C-Roads Platform, 2017).

- Personal transport vehicles assumed to have full model cycles of 7 years\(^\text{13}\) and public and freight transport assumed to have longer full model cycles of 9 years\(^\text{14}\). These model lifecycles were presented and validated at the stakeholder workshop.

- Bundles 4, 5 and 7 (Day 1.5 services) are not deployed in the baseline as observed in current C-ITS deployment projects. They are also not deployed in the three policy options modelled, but are included in the deployment scenarios (see Annex C).

- It is assumed that uptake rates in vehicles are the same across all countries, although penetration into the fleet differs by Member State due to different rates of fleet renewal.

Figure B-10 presents the uptake assumptions for Bundle 3\(^\text{15}\). There is no uptake of Bundle 1 or 2 in public transport in the baseline.

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\(\text{12}\) 2019 is also in line with the start year referenced in the European Commission’s C-ITS Strategy.

\(\text{13}\) "Vehicle model cycle" is the length of time that a particular vehicle model is on sale for before being replaced in the market by the next generation of that model. Assumed model cycle length of 7 years substantiated by analysis of the model cycles of 16 passenger car models (4 from each category).

\(\text{14}\) Stakeholders validated this assumption in the workshop held on 9\(^\text{th}\) February 2018. This assumption is the same as that used in the 2016 C-ITS Deployment study (Ricardo, 2016).

\(\text{15}\) Uptake charts for Bundles 1 & 2 would not show all vehicles, so Bundle 3 is chosen for illustration purposes.
B.2.2.2.2 Policy Options

In the Policy Options the uptake rates for vehicles accelerate compared to the baseline as described in Table B-5 presents the uptake assumption and Figure B-11 shows how these translate into uptake over time for each policy option.

Table B-5: Policy Options – Uptake assumptions for ITS sub-systems in new vehicles

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Transport</td>
<td>Same assumptions as baseline but with faster uptake. Maximum penetration reached after 4 full model cycles, starting 2019. (4x7 years = 28 years)</td>
<td>Maximum penetration reached in the same number of cycles (4) as PO1 but now using vehicle facelift cycles, starting 2019 (i.e. shorter cycle length of four years: 4x4 years = 16 years).</td>
<td>Uptake rates reflect mandate, reaching all cars in one full model cycle, starting in 2021.</td>
</tr>
<tr>
<td>Public Transport &amp; Freight</td>
<td>Same assumptions as personal transport but with longer model cycles, starting 2019. (4x9 years = 36 years)</td>
<td>Same uptake assumptions as personal transport but with longer facelift cycles, starting 2019. (4x5 years = 20 years)</td>
<td>All vehicles covered by 2030, starting 2021 (1 full model cycle).</td>
</tr>
</tbody>
</table>

Key assumptions and inputs:
- In PO1, the range of individual policies will result in greater user acceptance of services and provide more clarity for C-ITS providers resulting in increased uptake relative to the baseline. However, the majority of policies are non-binding guidelines and so deployment is restricted to where these guidelines are...
voluntarily applied. This is the option with the highest degree of uncertainty concerning the projected uptake. A conservative uptake duration of 4 full model cycles is assumed, supported by stakeholder feedback that it should be close to the baseline (where 5 model cycles is assumed).

- In PO2, it is assumed that C-ITS services can be delivered in new vehicles mid-model cycle, during their facelift cycles. This is due to defined specifications encouraging greater coordination, standardisation and confidence. Stakeholders at our February 2018 workshop agreed that it was reasonable to assume that C-ITS technology could be introduced mid-lifecycle.

- The only available literature to substantiate future C-ITS uptake were research forecasts by Visiongain/IHS market, for ITS-G5 and LTE-V2X respectively (Visiongain, 2016) (IHS Automotive, 2016) (IHS Markit, 2014). After an analysis by the study team and consultation with stakeholders these assumptions were considered to be too optimistic for the EU case when compared to the 2016 C-ITS study baseline. Instead, the Visiongain/IHS scenario was used as a basis to develop PO2 and sense check the resulting uptake.

- Cars are assumed to have facelift cycles of 4 years and public & freight transport assumed to have longer facelift cycles of 5 years.

- It is assumed that a mandate in PO3 would not be introduced until 2021.

- It is assumed that uptake rates in new vehicles are the same across all countries, although penetration into the fleet differs by Member State due to different rates of fleet renewal.

**Figure B-11: Uptake of C-ITS services in new personal vehicles in the Policy Options compared to baseline**

B.2.2.3.1 **Baseline**
For existing vehicles in the fleet, it is assumed that C-ITS services will only be accessed by retrofit through smartphones, which are equipped to deliver C-ITS services via a downloadable application. European sales of personal navigation devices (PND) have reduced from 17 million to 5 million between 2008 and 2016 [Statista, 2017], and smartphone C-ITS applications are already being developed (e.g. C-Mobile and NordicWay). Uptake rates for these personal ITS sub-systems are closely linked with the uptake in new vehicles. Table B-6 presents the uptake assumptions considered for personal ITS sub-systems in the baseline.

**Table B-6: Baseline - Uptake assumptions for personal ITS sub-systems in existing vehicles**

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Bundle 1</th>
<th>Bundle 2</th>
<th>Bundle 3</th>
<th>Bundle 4, 5 and 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Transport</td>
<td>No Uptake</td>
<td>Uptake in smartphones (assumed to be the only personal ITS devices) will start at the same time as in new vehicles. It progresses linearly, in line with uptake in new vehicles, following trajectory whereby maximum uptake (95%) in personal ITS devices would be reached when penetration in new vehicles reaches 100%.</td>
<td>Same assumption as for personal transport, but following uptake in new public transport vehicles, rather than passenger cars</td>
<td>No Uptake</td>
</tr>
<tr>
<td>Public Transport</td>
<td>No Uptake</td>
<td>Same assumption as for personal transport, but following uptake in new public transport vehicles, rather than passenger cars</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>No Uptake</td>
<td>Same assumption as for personal transport, but following uptake in new freight vehicles, rather than passenger cars</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key assumptions and inputs:**

- Personal ITS devices are assumed to involve smartphones only, and operate using a cellular network connection.
- Due to the population age distribution, there will always be a percentage that will not have a smartphone and so maximum uptake is limited to 95 percent.
- It is assumed that penetration for personal ITS devices is linked to the start year and maximum value of penetration in new vehicles. Feedback from an expert group meeting highlighted that C-ITS can already be provided by mobile phones and so it is reasonable to assume that uptake will at least begin in line with new vehicle C-ITS sub-system uptake. This is seen as a neutral assumption in the absence of data to support an assumption that deployment in smartphones will be increase more rapidly or more slowly than uptake in new vehicles.
- It is assumed that personal ITS devices are unable to deliver the safety V2V services of Bundle 1, although we acknowledge it may be possible in the future.
- Similar uptake rates are used for freight and passenger cars, although it is expected that the devices themselves and the business models for their inclusion will be different.

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16 Based on previous Ricardo work on C-ITS.
• It is assumed that uptake rates in vehicles are the same across all countries.

Figure B-12 below shows how uptake of C-ITS in personal ITS devices is related to uptake in new vehicles.
B.2.2.3.2 Policy Options

The only personal ITS devices modelled in this study are smartphones, for the reasons explained earlier. The scope of uptake of C-ITS bundles does not change from the baseline. The key difference between policy options is in the speed of deployment, which mirrors the speed of deployment in new vehicles. Moreover, in the policy options, like the baseline, uptake in smartphones will start when C-ITS system penetration in new vehicles starts. Feedback from an expert group meeting highlighted that C-ITS can already be provided by mobile phones and so it is reasonable to assume that uptake will at least begin in line with new vehicle C-ITS sub-system uptake. This is seen as a neutral assumption in the absence of data to support an assumption that deployment in smartphones will be slower or faster than uptake in new vehicles. Personal ITS device uptake increases linearly, to a maximum uptake of 95 percent when in-vehicle systems reach 100 percent.

B.2.2.4 Uptake of C-ITS services in infrastructure

B.2.2.4.1 Baseline

In this study, we divide EU countries into three country groupings (Front Runners, Planned Adopters, and Followers) according to the number of C-ITS projects in countries and the length of road network where the technology has been deployed. This is particularly important for infrastructure assumptions and uptake. Assumptions are also defined separately for infrastructure type (RSU or cellular) and for the 5 principle road types (TEN-T Corridor, Core TEN-T, Other Motorways, Other Interurban Roads and Urban Roads). Table B-7 provides an overview of the infrastructure uptake assumptions for the baseline.
Table B-7: Baseline - uptake assumptions for infrastructure in all country groupings

<table>
<thead>
<tr>
<th>Road type</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEN-T Corridor</td>
<td>Roadside unit (RSU): Use actual data on average deployment levels expected to be achieved by 2020 in each country grouping, with cap uptake in the year C-Roads runs out (2020). Cellular: assume an 84% coverage.</td>
</tr>
<tr>
<td>TEN-T Core</td>
<td>RSU: No uptake</td>
</tr>
<tr>
<td>Other Motorways (TEN-T Comprehensive)</td>
<td>Cellular: assume an 84% coverage</td>
</tr>
<tr>
<td>Other Interurban Roads</td>
<td>RSU: No uptake</td>
</tr>
<tr>
<td></td>
<td>Cellular: assume an 84% coverage</td>
</tr>
<tr>
<td>Urban</td>
<td>RSU/Cellular:</td>
</tr>
<tr>
<td></td>
<td>Front Runners 8% (traffic light stock that is replaced each year) x 25% (new traffic lights equipped) per year from 2020 Planned Adopters/Followers: uptake scaled based on TEN-T Core/Corridor uptake rates in Front Runners, and delayed by 2 and 4 years for each group respectively.</td>
</tr>
</tbody>
</table>

Key assumptions and inputs:

- Data from deployment projects within each country grouping (Front Runner, Planned Adopter, Follower) has been used to assess the percent of road network equipped with RSUs to 2020.

- In the baseline, it is assumed that from 2020 (when C-Roads ends) there will be no further installation of roadside units and the 2020 level is maintained until 2035. For Follower countries, that have no roll-out of C-ITS infrastructure to date this means that the baseline assumes no uptake in RSU infrastructure. While this is a conservative assumption, the high cost barriers for RSU roll-out due to interoperability issues and the resulting uncertainty around business models, will most likely mean that without additional EU funding being made available, these countries will not deploy on their own. While no RSU roll-out is assumed there will be still cellular infrastructure and in-vehicle deployment.

- The cellular coverage represents geographical coverage across the EU of 84 percent. For urban areas, we assume dedicated infrastructure will be required. In our modelling, we have used traffic light replacement as a proxy for this infrastructure rollout. In urban areas, it is assumed that 25 percent of new traffic lights are equipped with short-range transmitters beyond 2020. Deployment is calculated assuming a 12.5-year traffic light lifetime, which is based on consultation with stakeholders as part of the 2016 C-ITS Deployment study (Ricardo, 2016).

- An assessment of existing deployment projects in Front Runner countries has revealed an approximately 50:50 split between countries planning to deploy RSUs vs. using the cellular networks. As such, the weighted average infrastructure

---

17 The baseline assumes no further installation of C-ITS infrastructure beyond that resulting from existing or planned projects to 2020 (based on the year C-Roads projects conclude).
18 This is based on current average 4G/LTE geographic coverage for Europe (European Commission, 2016). In practice, we believe actual cellular coverage on transport routes is currently lower, but as we expect it to increase over time, we have used the current geographic coverage.
penetration for future years is based on this 50:50 split. We apply the same split for all country groupings as we expect other countries to follow the example of Front Runners in deployment. It is important to note that this represents the current observed situation but in the future, the split between cellular solutions and RSUs might change.

- A weighting between the infrastructure type (short-range or cellular communications) was calculated based on the communication technology employed in each deployment project. A count was made on the numbers of deployment projects in each Member State that were associated with short range, cellular or both technologies. The Member State count was aggregated for each country grouping and we then calculated a ratio between the two technologies. In line with a policy of technology neutrality, which has been favoured by the majority of deployment projects described in our case studies, the calculation indicated a 50:50 weighting between the two technologies for Front Runners, who have made the most progress. Consequently, this weighting has been adopted for other country groups as we expect they will eventually match the activity of Front Runners in the split of infrastructure type.

Figure B-13 and Figure B-14 present the uptake of RSU infrastructure in the baseline for each country grouping in TEN-T Corridor/Core and urban roads, respectively. Uptake on other motorways and other interurban roads is zero and uptake on all roads in Follower countries is zero in the baseline, based on average deployment levels to date in each country.

**Figure B-13: Uptake of RSU infrastructure in the baseline in Front Runner (FR), Planned Adopters (PA), and Followers (F) in TEN-T Corridor/Core roads**

![Uptake of RSU infrastructure in the baseline in Front Runner (FR), Planned Adopters (PA), and Followers (F) in TEN-T Corridor/Core roads](image)
With regards to central infrastructure the assumption is that once penetration along TEN-T corridors reaches 5%, a central C-ITS sub-system is required and when urban penetration reaches 10% another C-ITS sub-system is required. These figures are based on the stakeholder consultation during the 2016 deployment study, where experts indicated that this has to do with integration of C-ITS systems into traffic management centres – so would be required for both urban and motorways.

**B.2.2.4.2 Policy Options**

Infrastructure assumptions and resulting uptake are defined by country group. The key difference for these groups is the delay in uptake, although they will have similar uptake rates as the Front Runners in the policy options.
### Table B-8. Policy Options - uptake assumptions for infrastructure in Front Runners

<table>
<thead>
<tr>
<th>Road type</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEN-T Corridor</td>
<td>RSU: Use actual data on average deployment levels expected to be achieved by 2020. From 2020, project the trajectory at <strong>25%</strong> of the deployment rate between 2015 and 2020. Cellular: assume an 84% coverage</td>
<td>RSU: Use actual data on average deployment levels expected to be achieved by 2020. From 2020, project the trajectory at the <strong>same rate</strong> as deployment rate between 2015 and 2020. Cellular: assume an 84% coverage</td>
<td>RSU: Use actual data on average deployment levels expected to be achieved by 2020. From 2021, project the trajectory at <strong>150%</strong> of the deployment rate between 2015 and 2020, triggered by the in-vehicle mandate. Cellular: assume an 84% coverage</td>
</tr>
<tr>
<td>TEN-T Core</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEN-T Comprehensive</td>
<td>RSU: No uptake</td>
<td></td>
<td>RSU: From 2020, project the uptake rate of TEN-T Corridor and Core roads at <strong>50% of the uptake rate</strong>. Cellular: assume an 84% coverage</td>
</tr>
<tr>
<td>Non-Urban Non-Motorway</td>
<td>Cellular: assume an 84% coverage</td>
<td>RSU: From 2020, project the uptake rate of TEN-T Corridor and Core roads at <strong>25% of the uptake rate</strong>. Cellular: assume an 84% coverage</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>RSU &amp; Cellular: 8% (traffic light stock that is replaced each year) x 50% (new traffic lights equipped) per year from 2020</td>
<td>RSU &amp; Cellular: 8% x 75% per year from 2020</td>
<td></td>
</tr>
</tbody>
</table>

**Key assumptions and inputs:**
- From PO2, RSU uptake is applied to the wider road network, but at reduced rates relative to TEN-T Corridor/Core uptake.
- Activity is expected to be focused on TEN-T corridor and core roads in the policy options, with diminishing activity for smaller roads.
- The increased infrastructure uptake in PO3 starts in 2021, in line with the mandate for penetration in new vehicles - it is expected to trigger additional infrastructure uptake.
Table B-9. Policy Options - uptake assumptions for infrastructure in Planned Adopters (PA) and Followers (F)

<table>
<thead>
<tr>
<th>Road type</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEN-T Corridor</td>
<td>RSU: Use actual data on average deployment levels expected to be achieved by 2020. From 2020, the uptake follows the same trend as the TEN-T roads in Front Runners, however starting at a lower level of penetration. Cellular: assume an 84% coverage</td>
<td>RSU: Use actual data on average deployment levels expected to be achieved by 2020 and projected to 2021. From 2021, the uptake follows the same trend as the TEN-T roads in Front Runners, i.e. reflecting the in-vehicle mandate triggering an increased infrastructure uptake Cellular: assume an 84% coverage</td>
<td></td>
</tr>
<tr>
<td>TEN-T Core</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Motorways (TEN-T Comprehensive)</td>
<td>RSU: No uptake Cellular: assume an 84% coverage</td>
<td>RSU: Uptake follows the same uptake trend as the Comprehensive and Non-Urban roads in Front Runners, with an uptake start date delayed by 2 and 4 years for PA and F respectively. Cellular: assume an 84% coverage</td>
<td></td>
</tr>
<tr>
<td>Other Interurban Roads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>RSU: Uptake follows the same uptake trend as the Urban roads in Front Runners, with an uptake start date delayed by 2 and 4 years for PA and F respectively. Cellular: assume an 84% coverage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key assumptions and inputs:

- It is assumed that legislation will have the same impact on uptake trends in all countries as the conditions for deployment will be the same. Therefore, uptake in Planned Adopters and Followers follows the respective uptake in Front Runners.
- For TEN-T Corridor/Core roads, there is reduced uptake between the country groupings due to different penetration levels in 2020. From 2020, uptake is influenced by the regulations in each policy option.
- For other roads, reduced uptake between the country groupings is modelled using a delayed uptake start date of 2 and 4 years for Planned Adopters and Followers respectively.
The assumptions on deployment of central C-ITS sub-systems are identical to the ones in the baseline i.e. once penetration along TEN-T corridors reaches 5%, a central C-ITS sub-system is required and when urban penetration reaches 10% another C-ITS sub-system is required.
Figure B-17 display the RSU infrastructure uptake assumptions for TEN-T Core and Corridor roads translated into uptake rates for each country grouping.

**Figure B-17. Uptake of RSU infrastructure in TEN-T Corridor/Core roads of Front Runners**

![Graph showing RSU infrastructure uptake for Front Runners]

**Figure B-17. Uptake of RSU infrastructure in TEN-T Corridor/Core roads of Planned Adopters**

![Graph showing RSU infrastructure uptake for Planned Adopters]

**Figure B-17. Uptake of RSU infrastructure in TEN-T Corridor/Core roads of Followers**

![Graph showing RSU infrastructure uptake for Followers]
Figure B-20 presents the uptake rates for RSU infrastructure across all road types in Policy Option 3. Uptake across roads in PO2 has a similar relationship but at a lower rate. In PO1, uptake is lower than in PO2 and there is no uptake in other motorways and other inter-urban roads.

**Figure B-20. Uptake of RSU infrastructure in PO3 for**

**Front Runners across all roads**

**Figure B-20. Uptake of RSU infrastructure in PO3 for**

**Planned Adopters across all roads**

**Figure B-20. Uptake of RSU infrastructure in PO3 for**

**Followers across all roads**
B.2.3 C-ITS service impact data

B.2.3.1 Introduction

This section presents the environmental and socio-economic impacts of the C-ITS services that are considered in this study. Impacts can be in terms of traffic efficiency, fuel consumption, pollutant emissions, or accident rates. These are the impacts on individual vehicles when C-ITS services are installed across the different vehicle and road types.

The impact values are combined with bundle uptake and penetration rates in the scenario model, and then input into the ASTRA/TRUST model to estimate the total EU-level impact of services for each deployment scenario. The EU-level impacts are then converted to monetary benefits in the CBA by using typical values for the external cost of transport from the Handbook on External Costs of Transport (Ricardo-AEA et al., 2014).

In the 2016 C-ITS deployment study (Ricardo-AEA, 2016), data was collected on the impacts of C-ITS services, through expert input and an extensive literature review. The project team has sought out additional input data to update this existing database (see Section B.2.3.3).

From the literature review and feedback from the stakeholder engagement tasks as part of this study, there was a limited amount of new data available and little consensus among stakeholders on the existing impact data. Therefore, many of the impact values from our 2016 have been retained but we have noted where values have been updated.

While there is little to no overlap between the baseline for this study and the RIMS/GSR baseline for the technologies, there are some overlapping impacts. This is due to the overlapping effects between the impacts of the policies, in the same way as there is nearly always more than one factor in accident causation. The individual influence of each factor is virtually impossible to determine. In other words, the combined effect of road infrastructure, vehicle safety and C-ITS measures deployed together, is going to be somewhat lower than the sum of their individual effects. Under GSR predicted impacts, accidents (the only impact modelled) reduce by 7-8 percent in the policy options. For this reason, we have reduced the benefit of C-ITS services on safety by 10 percent across all C-ITS services in our study in the baseline and policy options modelled. This reduction will more than account for any overlaps between the effect of C-ITS services on safety and those of the RISM/GSR Regulations. For this reason, our baseline is stronger than the RISM/GSPR baselines.

This 10% reduction is implemented in the models and not reflected in the impact values in this annex. The impacts modelled are the maximum impacts assuming 100% penetration, which are then scaled to actual C-ITS uptake and applied to transport activity in the TRT models.

The table below summarises the C-ITS service impacts:
### Table B-10. Summary of impact of each C-ITS service considered.

<table>
<thead>
<tr>
<th>Service</th>
<th>Impact</th>
<th>Safety</th>
<th>Fuel Consumption</th>
<th>Pollutant Emissions</th>
<th>Congestion/Travel time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency electronic brake light (EBL)</td>
<td></td>
<td>2.7% reduction in fatalities and 2.5% reduction in other accidents, across all road types</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
<tr>
<td>Emergency vehicle approaching (EVA)</td>
<td></td>
<td>0.8% reduction in all accident types, across all road types</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
<tr>
<td>Hazardous location notification (HLN)</td>
<td></td>
<td><strong>Fatalities:</strong> 3.6% reduction on motorways 3.7% reduction on other interurban roads 1.2% reduction on urban roads <strong>Other accident types:</strong> 3.7% reduction on non-urban roads 1.3% reduction on urban roads</td>
<td>No impact</td>
<td>No impact</td>
<td>2% increase in speed across all vehicle types on urban roads</td>
</tr>
<tr>
<td>Slow or stationary vehicle(s) (SSV)</td>
<td></td>
<td>1.1% reduction in fatalities and 0.7% reduction in other accidents, across all road types</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
<tr>
<td>Traffic jam ahead warning (TJW)</td>
<td></td>
<td><strong>Fatalities:</strong> 2.4% reduction on motorways 2.0% reduction on other interurban roads 1.2% reduction on urban roads <strong>Other accident types:</strong> 4.4% reduction on motorways 3.7% reduction on other interurban roads 1.8% reduction on urban roads</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
</tbody>
</table>

Ref: Ricardo/ED10644/4
<table>
<thead>
<tr>
<th>Feature</th>
<th>Fatality Reduction</th>
<th>Other Accident Types:</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-vehicle signage (VSGN)</td>
<td>1.0% reduction on motorways, 1.3% reduction on other roads</td>
<td>No impact</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-vehicle speed limits (VSPD)</td>
<td>6.9% reduction in fatalities and a 3.9% reduction in injuries, applied to passenger cars and freight for all road types</td>
<td>2.3% fuel saving on motorways and a 3.5% fuel saving on other interurban roads</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probe vehicle data (PVD)</td>
<td>3.3% reduction on motorways, 2.8% reduction on other interurban roads, 1.6% reduction on urban roads</td>
<td>4.9% reduction on motorways, 4.1% reduction on other interurban roads, 2.0% reduction on urban roads</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road works warning (RWW)</td>
<td>1.3% decrease in fatalities and a 1.1% decrease in injuries across all road types. Not applicable to public transport</td>
<td>No impact</td>
</tr>
</tbody>
</table>

**NOx:** 0.5% reduction (motorways), 0.4% reduction (other interurban roads)

**PM:** 0.4% reduction (motorways), 4.2% increase (other interurban roads)

**CO:** 0.2% reduction (motorways), 0.2% increase (other interurban roads)

**VOCs:** 0.1% increase (motorways), 0.5% increase (other interurban roads)

**1.40%** reduction in vehicle speed in urban areas

Ref: Ricardo/ED10644/4
<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
<th>Impact</th>
<th>Impact</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shockwave Damping (SWD)</td>
<td>7.8% decrease in fatalities and a 5.0% decrease in injuries on motorways. Not applicable to public transport</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
<tr>
<td>Weather conditions (WTC)</td>
<td>3.4% decrease in all accident types. Not applicable to public transport</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
<tr>
<td>Green Light Optimal Speed Advisory (GLOSA) / Time To Green (TTG)</td>
<td>0.1% decrease in fatalities on both urban and rural roads, and a 0.1% and 0.3% decrease in injuries on rural and urban roads respectively.</td>
<td>0.1% reduction in fuel consumption on other-interurban roads and a 0.7% reduction in fuel consumption on urban roads.</td>
<td>NOx: 0.1% reduction (other interurban roads), 0.2% reduction (urban roads) PM: 0.1% decrease (other interurban roads) CO: 0.3% reduction (other interurban roads), 0.8% increase (urban roads) VOCs: 0.5% increase (other interurban roads), 0.6% increase (urban roads)</td>
<td>No impact</td>
</tr>
<tr>
<td>Signal violation / Intersection Safety (SigV)</td>
<td>3.8% reduction in fatalities and a 7.0% reduction in injuries across all vehicle types, on urban and other interurban roads</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
<tr>
<td>Traffic signal priority request by designated vehicles (TSP)</td>
<td>No impact</td>
<td>8.3% reduction in fuel consumption across all buses in urban environments</td>
<td>NOx: 8.0% reduction (buses on urban roads) PM: 8.2% reduction (buses on urban roads) CO: 8.3% reduction (buses on urban roads) VOCs: 8.3% reduction (buses on urban roads)</td>
<td>9.2% reduction in travel time for buses</td>
</tr>
<tr>
<td>Information on fuelling &amp; charging stations for alternative fuel vehicles (iFuel)</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
</tbody>
</table>

Ref: Ricardo/ED10644/4

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Off Street Parking Information (Pinfo)</th>
<th>On Street Parking Management and Information (PMang)</th>
<th>Park &amp; Ride Information (P&amp;Ride)</th>
<th>NOx: 0.3% reduction (passenger and freight vehicles on urban roads)</th>
<th>PM: 0.1% reduction (passenger and freight vehicles on urban roads)</th>
<th>CO: 0.8% reduction (passenger and freight vehicles on urban roads)</th>
<th>VOCs: 0.8% reduction (passenger and freight vehicles on urban roads)</th>
<th>0.6% reduction in travel time in urban areas across passenger and freight vehicles.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
<td>0.8% reduction in fuel consumption across passenger and freight vehicles in urban environments.</td>
<td>0.8% reduction in fuel consumption across passenger and freight vehicles in urban environments.</td>
<td>0.8% reduction in fuel consumption across passenger and freight vehicles in urban environments.</td>
<td>0.8% reduction in fuel consumption across passenger and freight vehicles in urban environments.</td>
<td>0.8% reduction in travel time in urban areas across passenger and freight vehicles.</td>
</tr>
</tbody>
</table>

**Ref**: Ricardo/ED10644/4
<table>
<thead>
<tr>
<th>Traffic information &amp; Smart routing (SmartR)</th>
<th>No impact</th>
<th><strong>1.9%</strong> reduction in fuel consumption for passenger and freight vehicles across all road types.</th>
<th><strong>NOx</strong>: <strong>0.4%</strong> reduction (motorways), <strong>1.7%</strong> reduction (other interurban roads), <strong>0.5%</strong> reduction (urban roads) <strong>PM</strong>: <strong>0.3%</strong> reduction (motorways), <strong>0.8%</strong> reduction (other interurban roads), <strong>0.1%</strong> reduction (urban roads) <strong>CO</strong>: <strong>0.2%</strong> reduction (motorways), <strong>4.2%</strong> reduction (other interurban roads), <strong>2.3%</strong> reduction (urban roads) <strong>VOCs</strong>: <strong>0.1%</strong> increase (motorways), <strong>6.5%</strong> reduction (other interurban roads), <strong>1.7%</strong> reduction (urban roads)</th>
<th><strong>8%</strong> reduction in travel time in urban areas for both passenger and freight vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vulnerable Road user protection (VRU)</td>
<td><strong>1.8%</strong> reduction in fatalities and a <strong>1.9%</strong> reduction in injuries for other interurban roads and urban roads, applied to all vehicle types</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
</tbody>
</table>

Ref: Ricardo/ED10644/4
B.2.3.2 C-ITS service impact data overview

Impact data collected

For each C-ITS service included in the C-ITS deployment scenarios, data related to the following parameters was collected:

1. **Traffic efficiency** i.e. the percentage change in average speed for a vehicle equipped with C-ITS services.
2. **Fuel consumption** i.e. the percentage change in fuel consumption for a vehicle equipped with C-ITS services.
3. **Polluting emissions** i.e. the percentage change in NO\(_x\), CO, VOC and PM emissions for a vehicle equipped with C-ITS services.
4. **Safety** i.e. the percentage change in accident rates (classified by fatalities, serious injuries, light injuries and material damages) for a vehicle equipped with C-ITS services.

Impacts categorisation

C-ITS services can have varying impacts depending on the road type and vehicle type in which they are deployed. Furthermore, some services are not applicable to some road or vehicles types. Where available, impact data was therefore collected for the road and vehicle types modelled.

Key assumptions

In most cases, data was collected for services at maximum effectiveness, i.e. at 100% deployment in infrastructure and in the vehicle fleet. In the case of DRIVE C2X, the high scenario was used as an input to the modelling\(^\text{19}\). Wherever sufficiently robust data was available from multiple sources, average impacts were calculated as inputs to the modelling. For further details, see the individual service descriptions in Section B.2.3.4.

The actual effectiveness applied in the ASTRA and TRUST modelling is estimated through maximum effectiveness alongside the predicted vehicle/aftermarket and infrastructure penetration rates.

In future years, it is conceivable that C-ITS technology could improve to deliver greater impacts. However, the modelling assumes that there will be no improvement in technology/performance over the time period covered in this cost-benefit analysis (2015–2035).

Whilst our objective was to collect data for each road and vehicle type we model, the information comes primarily from C-ITS deployment projects and an extensive search of the literature revealed that detailed, publicly available results are extremely limited, despite a number of deployment projects carried out in Europe in recent years. Where necessary, a number of assumptions were employed to fill the data gaps:

- Impact data was not available for individual vehicle types; therefore, impacts were assumed to be the same for all vehicle types.
- Safety impacts were collected for fatalities and injuries wherever possible. Where this split was available, it was assumed that the magnitude of accident impacts would be the same for serious injuries, light injuries and material damages. Where this split was not available, the impact was assumed to be the same across all accident types.
- Impact data was collected for different road types wherever possible. In the case of data gaps, it was assumed that impacts would be the same on all road types.

\(^{19}\) The high scenario in DRIVE C2X is based on the high impact estimate for DRIVE C2X C-ITS services and an overall fleet penetration of 76%, which takes into account 100% penetration in passenger cars and zero uptake in public transport and freight vehicles.
where the service was seen as relevant (in these cases, urban-focused services were not applied to inter-urban roads and vice versa).

Furthermore, change in speed is only modelled on urban roads in TRT’s ASTRA model, therefore traffic efficiency data was not modelled for motorways (TEN-T corridors, TEN-T core roads and the comprehensive TEN-T network) and other inter-urban roads.

B.2.3.3 Sources of information

The following section presents the literature and expert input contributions to the gathering of C-ITS service impact data. The methodology and sources from the 2016 study are presented along with the review and update activities carried out in this study.

Literature

In this study, 26 deployment projects were identified for analysis. These include new projects that started since the previous study and projects that were identified but had not published results. A number of new projects, including the C-Roads platform, InterCor, NordicWay and C-the Difference were highlighted as case studies, and are presented in Annex D. Initiatives providing coordination and support activities were also reviewed as they are a useful resource that reference a number of new projects. Furthermore, online searches on FOT-Net Wiki\textsuperscript{20} and TRIMIS\textsuperscript{21} were carried out, as well as internet searches. A number of projects, namely C-Roads, are still in progress and have not published results yet. From projects other than C-Roads, only impact data from NordicWay has been used to update C-ITS service impact data.

\textsuperscript{20} http://wiki.fot-net.eu/index.php/Welcome_to_the_wiki_of_Field_OperationalTests

\textsuperscript{21} https://trimis.ec.europa.eu/
The impacts data collection exercise built on an extensive literature review of over 100 documents, which covered various aspects of C-ITS services and related technologies. Within this long list, we identified a number of key sources for the cost data collection task:

- EasyWay Business case and benefit-cost assessment of EasyWay priority cooperative services (Kulmala et al., 2012)
- SAFESPOT Deliverable SP6 – BLADE – Business models, Legal Aspects, and Deployment (Luedeke et al., 2010)
- CODIA Deliverable 5 – Final study report (Kulmala et al., 2008)
- eSafetyForum Intelligent Infrastructure Working Group – Final Report (op de Beek et al., 2010)
- TNO Impact of Information and Communication Technologies on Energy Efficiency in Road Transport – Final Report (Klunder et al., 2009)
- COMeSafety2 D2.3 Cost Benefits Analysis & Business Model Elements for Deployment (Ségarra et al., 2014)
- iMobility Effects database (eSafety and iCarSupport, n.d.)

The most commonly used data sources are described in more detail in a series of boxes when they are first referenced throughout this document.

Where C-ITS service impact data was not directly available from literature, a number of approaches were used to fill the data gaps, including:

- Identifying impacts from other non-C-ITS services or technologies which are expected to operate through a similar mechanism to specific C-ITS services, for example ‘lane change assist’ as one component of the Day 1.5 service Cooperative Collision Risk Warning.
- Estimating impacts - for example using known accident data linked to specific accident types targeted by certain C-ITS services to estimate the impact of a specific C-ITS service on accident rates.

The detailed assumptions used for each C-ITS service are listed under each service heading in Section B.2.3.4 Impact data by service.

**Expert input**

Specific data requests were distributed to 18 relevant stakeholders including deployment projects, automotive associations and manufactures. The team received three responses relating to impact data. Values provided by a NordicWay project representative were used to update two services. In addition to this, a stakeholder workshop was conducted in February 2018 with over 140 participants. Model inputs, including impact data, were presented and participants were encouraged to provide feedback during the workshop and via an online survey that was open for 2 weeks following the event. The team received 28 survey responses of which 18 were completed responses with data feedback that could be used. A number of the responses related to the impact data, however no new data was provided and there was little consensus about whether values were too high or too low. In these cases, we retained the existing values.
B.2.3.4 Impact data by service

Emergency electronic brake light (EBL)

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

Service overview

The emergency electronic brake light is a service aimed at preventing rear end collisions by informing drivers of hard braking by vehicles ahead. Using this information, drivers will be better prepared for slow traffic ahead and will be able to adjust their speed accordingly.

Technical information

- Day 1 vehicle-to-vehicle (V2V) service
- Bundle 1

In response to a vehicle suddenly braking, a message is sent to following vehicles to warn drivers of an abrupt decrease in traffic speed ahead. Emergency electronic brake lights are displayed in the following vehicles, giving drivers the opportunity to adjust their speed to avoid a potential collision. This service is applicable on all road and vehicle types, although it is envisaged to be particularly useful on congested, high speed roads, or in areas where visibility is poor. In this situation, following vehicles may not be able to see the brake lights of all vehicles ahead of them and would therefore have very limited time to react to hard braking without the service. This service currently predominantly relies on V2V ITS-G5 communication, although a number of projects are looking to demonstrate its effectiveness using high-speed (e.g. 4G/5G) cellular networks.

Impact data

The main data source for the impacts of the emergency electronic brake light was from FOTs in the DRIVE C2X project (TNO et al., 2014). An overview of the general methodology is provided in Box B-1. This service was only tested in Germany, in partnership with the simTD project (simTD, 2013). A US DoT cost-benefit analysis report was also used as a comparison (John A. Volpe National Transportation Systems Center, 2008).

Box B-1: Overview of key data source – DRIVE C2X project

The DRIVE C2X project used log data resulting from Field Operational Tests (FOTs) carried out on several test sites in different EU countries (Finland, France, Germany, Italy, the Netherlands, Spain, and Sweden).

The study aimed to harmonise the testing conditions as far as possible, in order to allow the data across the pilot sites to be combined. Nevertheless, several aspects differed significantly from one test site to others. These differences can be explained by cultural, country specific aspects as well as acquisition related influences (private drivers vs. employees).

The FOTs focused on functions that provide information or warnings to drivers. This means that the impact is dependent on whether and how the driver responds. Thus, the impact assessment first aimed to measure driver behaviour in order to provide input data for an impact assessment in four target areas: safety, efficiency, mobility, and environment.

Driver behaviour data was collected in two main ways: controlled tests” (CTs) and naturalistic driving (ND). In CT, drivers were called into the test and followed the driving instructions provided by the Test-Site Instructor, allowing the driver to encounter specific test situations. In the ND approach, drivers were monitored in their daily driving. Data on driver behaviour was then pooled across the test sites and used as input for the assessment of impacts.
Safety impacts were calculated by making use of the results of the field tests regarding driver behaviour, expert assessment and previous expert assessments found in the literature. Traffic efficiency and environmental impact assessment made use of simulation models. The mobility impact assessment in DRIVE C2X was based on the mobility model developed in TeleFOT project. The mobility assessment data consisted of user interviews (questionnaires and focus groups) based on experience in real traffic. The scaling up of the effects to the EU-level made use of external data.

Source: (TNO et al., 2014)

Other studies that considered the impacts include the eIMPACT project (TNO, VTT, Movea, PTV, BASt, 2008) and a cost-benefit analysis performed for the U.S. Department of Transport (John A. Volpe National Transportation Systems Center, 2008). We have chosen to prioritise the DRIVE C2X data ahead of these source as it was published in 2014 (compared to 2008 for the other sources), is based on FOT data and its primary focus is on the EU, compared to the US DoT study.

Traffic efficiency

The primary effect of emergency electronic brake light is intended to be on safety, hence the traffic efficiency impacts are expected to be minimal. No traffic efficiency effects are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider traffic efficiency effects for this service.

Fuel consumption and CO₂

The primary effect of emergency electronic brake light is intended to be on safety, hence the fuel efficiency impacts are expected to be minimal. No fuel efficiency benefits are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider the effect on fuel consumption for this service.

Environmental and emissions impacts

The primary effect of emergency electronic brake light is intended to be on safety, hence the emissions impacts are expected to be minimal. No effects on emissions are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider the effect on polluting emissions for this service.

Safety

The primary objective of this service is to prevent rear end collisions, although other types of accident may also be prevented. Specifically, this service is thought to reduce the number of panic manoeuvres performed by vehicles, due to the early warning. This service can act via two mechanisms (TNO et al., 2014):

- Direct in-vehicle modification of the driver task – the driver behind the braking vehicle has more time to react to the braking vehicle ahead.
- Modification of interaction between vehicles – following drivers (with or without emergency brake light capability) will also have more time to react to the braking vehicle ahead.

In the DRIVE C2X study, impacts were assessed separately for: a) motorways and high speed rural roads (with a speed limit of at least 80 km/hour) and b) urban roads and low speed rural roads. The assumptions made in the DRIVE C2X study in scaling up these impacts are detailed below (TNO et al., 2014).

Rear-end collisions prevented via direct in-vehicle modification of the driving task:
60-80% of fatalities and injuries on rural roads occur on high speed rural roads, whilst all fatalities and injuries on motorways are considered to be high-speed (>80km/h).

It is assumed that 50-70% of rear end collisions occurring on motorways and high speed rural roads could be influenced by the emergency brake light service.

- 20-30% of these fatalities and injuries could be prevented by the emergency electronic brake light.

It is assumed that 10-25% of rear end collisions occurring on urban roads and low speed rural roads (the remaining 20-40% of rural roads) could be influenced by the emergency brake light service.

- 30-40% of these fatalities and injuries could be prevented by the emergency electronic brake light.

Other collision types (other than rear-end) prevented via direct in-vehicle modification of the driving task:

- Magnitude of the safety benefit was estimated to be 5-10% of the impact for rear collisions (as described above) per accident type.

Rear-end collisions prevented via modification of interaction between road users:

- When a driver reacts to hard braking ahead, following vehicles will also have increased time to react.
  - On motorways and high speed rural roads, a 0.10-0.15% reduction in fatalities is expected.
  - On motorways and high speed rural roads, a 0.02-0.03% reduction in injuries is expected.
  - On urban roads and low speed rural roads, a 0.15-0.30% reduction in fatalities is expected.
  - On urban roads and low speed rural roads, a 0.10-0.20% reduction in injuries is expected.

The relatively low effectiveness of this service for interactions between road users is due to the high element of surprise and very small time margins involved in these types of crashes.

Overall for the EU-28, the DRIVE C2X study calculated a decrease in fatalities between 25 and 304 in 2030 and a decrease in injuries between 1,322 and 16,219 in 2030.

The DRIVE C2X high penetration scenario was used as an input to the model, which corresponds to a 2.7% decrease in fatalities and a 2.5% decrease in injuries.

The US DoT also assessed the potential safety impact of this service in 2030 as part of a cost-benefit analysis and calculated a 0.88% decrease in annual light vehicle crashes, which is a significantly lower figure than DRIVE C2X (John A. Volpe National Transportation Systems Center, 2008). The discrepancy is likely to be due to the differences in road and driving characteristics in the USA and EU and higher traffic density on European roads.

Other impacts

As part of DRIVE C2X, user acceptance tests were not carried out for the emergency brake light functionality. The simTD project reported that driver behaviour was not significantly affected by the emergency brake light, however recommends further studies to support this theory (Mühlbacher, 2013). The simTD project questions whether there are benefits for drivers further behind the braking vehicle and again proposes that further research should be carried out to determine the impact of this service on all vehicles in a queue.
Emergency vehicle approaching (EVA)

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

Service overview

This service aims to give an early warning of approaching emergency vehicles, prior to the siren or light bar being audible or visible. This should allow vehicles extra time to clear the road for emergency vehicles and help to reduce the number of unsafe manoeuvres.

Technical information

- Day 1 V2V service
- Bundle 1

Approaching emergency vehicles will communicate with vehicles ahead to warn drivers to clear the road. The advance warning provided by this service will give vehicles extra time to clear the road for approaching emergency vehicles in a safe and timely manner. This service is applicable for all road and vehicle types. This service currently predominantly relies on V2V ITS-G5 communication, although a number of projects are looking to demonstrate its effectiveness using high-speed (e.g. 4G/5G) cellular networks.

Impact data

The main data source for the impacts of the emergency vehicle approaching service was the DRIVE C2X project (TNO et al., 2014). An overview of the general methodology is provided in Box B-1. Trials of this service were carried out at test sites in Germany, Italy and Spain. Data for this service was very limited, perhaps due to the limited real world opportunities to trial this type of service. To our knowledge, there are no other publicly available studies that examine the emergency vehicle approaching service specifically.

Traffic efficiency

The primary effect of the emergency vehicle approaching service is intended to be on safety, hence the traffic efficiency impacts are expected to be minimal. No traffic efficiency effects are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider traffic efficiency effects for this service.

Fuel consumption and CO₂

The primary effect of the emergency vehicle approaching service is intended to be on safety, hence the fuel efficiency impacts are expected to be minimal. No fuel efficiency benefits are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider the effect on fuel consumption for this service.

Environmental and emissions impacts

The primary effect of the emergency vehicle approaching service is intended to be on safety, hence the emissions impacts are expected to be minimal. No effects on emissions are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider the effect on polluting emissions for this service.

Safety

A reduction in collisions can be expected when this service is implemented due to the increased time drivers have available to inform their driving decisions.

The DRIVE C2X study used French accident statistics to estimate the impact of the emergency vehicle approaching warning (TNO et al., 2014). These show that 0.8% of fatal accidents and 1.1% of injuries included an emergency vehicle. This does not include
accidents where the emergency vehicle was not directly involved. A multiplier of 1-5 was used for these accidents, based on another study (Clawson, 1997). Of these additional accidents, it was estimated that only 1-5% would result in injuries or fatalities.

The accidents were then categorised according to whether they occurred at an intersection or on a link section of road. Here, the following assumptions were made:

- 50-70% of emergency vehicle related (directly or indirectly) fatalities and injuries occur at intersections (Auerbach, 1988; Elling, 1988).
- 50-70% of emergency vehicle related (directly or indirectly) fatalities and injuries occurring at intersections could be prevented by the emergency vehicle approaching service.
- 60-80% of emergency vehicle related (directly or indirectly) fatalities and injuries occurring at links (the remaining 30-50% of total fatalities and injuries) could be prevented by the emergency vehicle approaching service. This higher figure is due to the lower complexity of the road layout and reflects the fact that it is likely to be easier for drivers to give way to emergency vehicles.

The results in the DRIVE C2X report were presented in terms of the overall impact in the EU-28 in 2030. It was estimated that 14-84 fatalities and 933-4954 injuries could be prevented (TNO et al., 2014). The high scenario in DRIVE C2X equates to a 0.8% reduction in fatalities and a 0.8% reduction in injuries.

Other impacts

A survey of test participants during the DRIVE C2X study revealed some interesting insights regarding this service. 92% of participants viewed the service as useful (the highest in the study), however only 41% indicated they would be willing to pay for this feature (TNO et al., 2014). On a scale of 1 to 7, the average increased feeling of safety was rated at 5.6-6.0, suggesting that this service can offer an improved driving experience.

**Slow or stationary vehicle(s) warning (SSV)**

*The impact data presented in this section are from the 2016 C-ITS deployment study.* (Ricardo-AEA, 2016).

**Service overview**

Slow or stationary vehicle(s) warning is intended to deliver safety benefits by warning approaching drivers about slow or stationary/broken down vehicle(s) ahead, which may be acting as obstacles in the road. The warning helps to prevent dangerous manoeuvres as drivers will have more time to prepare for the hazard. This service can also be referred to as car breakdown warning.

**Technical information**

- Day 1 V2V service
- Bundle 1

Slow or stationary vehicle(s) signal to nearby vehicles to warn approaching drivers of their presence. These messages can then be relayed to following drivers, who can consequently plan to take an alternative route, or make evasive manoeuvres, thus improving traffic fluidity, safety and delivering efficiency benefits. This service is applicable to all road and vehicle types. As for the emergency electronic brake light service, it is anticipated that this service will be especially useful for warning vehicles of the potential danger of a rear end collision when visibility is poor. This service currently predominantly relies on V2V ITS-G5 communication, although a number of projects are looking to demonstrate its effectiveness using high-speed (e.g. 4G/5G) cellular networks.

**Impact data**
The main data source for the impacts of slow or stationary vehicle(s) warning was the DRIVE C2X project (TNO et al., 2014). An overview of the general methodology is provided in Box B-1. This service was tested at sites in Finland, Italy, Spain and Sweden. In DRIVE C2X, this service is evaluated alongside ‘obstacle warning’ and ‘roadworks warning’, as the services perform a similar function, act via similar mechanisms and present information to drivers in a similar manner.

The eIMPACT project (TNO et al., 2014) evaluated the impacts of a service called ‘wireless local danger warning’, which is based on V2V communication. An overview of the general methodology is provided in Box B-2. The eIMPACT definition of this service includes both obstacle/stationary vehicle warning and weather warning functionality.

**Box B-2: Overview of key data source – eIMPACT project**

The eIMPACT project assessed the socio-economic effects of Intelligent Vehicle Safety Systems (IVSS) and their impacts on safety and traffic efficiency. Results from the impact assessment (Deliverable D4) were then used to inform a cost-benefit analysis (Deliverable D6).

The results of the study were published in 2008 and calculated the potential impacts of IVSS in the years 2010 and 2020. The impact assessment was performed for low (business as usual) and high (policy incentives) scenarios for both years. For each scenario, the fleet penetration varied by service, vehicle type (passenger car or goods vehicle) and by year (2010 or 2020). In addition to the scenarios, the maximum effectiveness of each service based on 100% penetration at EU-25 level was also calculated as part of eIMPACT. Results were given for the EU-25 as a whole and are not separated by road type, or vehicle type. We have used the values based on 100% penetration as a source of data in this project.

Twelve services were evaluated, although only three were defined as having cooperative functionality:

- **Intersection safety** - the description of this service in the eIMPACT report also includes GLOSA/TTG functionality and is not limited to signalised intersections (also provides right of way assistance and left turn assistance).
- **Speed alert** - considers the service to have V2I functionality in 2020 but not in 2010.
- **Wireless local danger warning** - includes weather warnings and obstacle/stationary vehicle warnings, both of which are based on V2V communication.

Another service, pre-crash protection of vulnerable road users, was also evaluated. This is similar to the vulnerable road user protection service evaluated in this study, however in eIMPACT it was not considered to be a cooperative system and was assumed to operate by detecting vulnerable road users via sensors. The two services are likely to present information to the driver in a similar manner and safety impacts will occur via similar mechanisms, therefore we believe the data presented can be of some value.

Safety impacts were calculated by making use of expert estimations and were scaled up to EU-25 level based on current accident statistics. In addition to this, consultation with key stakeholders was an integral part of the eIMPACT project.

Sources: (TNO, VTT, Movea, PTV, BASt, 2008) (eImpact, 2008)

**Traffic efficiency**

The traffic efficiency impacts of the slow or stationary vehicle(s) service are expected to be minimal as its purpose is to improve safety, rather than prevent traffic jams (TNO et al., 2014). In addition to this, broken down, stationary, or exceptionally slow vehicles (such as tractors) on the road are relatively infrequent events, therefore effects on traffic on an EU level will be negligible. This impact is therefore not included in our model.

**Fuel consumption and CO₂**
The primary effect of the slow or stationary vehicle warning is intended to be on safety, hence the fuel efficiency impacts are expected to be minimal. No fuel efficiency benefits are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider the effect on fuel consumption for this service.

**Environmental and emissions impacts**

The primary effect of the slow or stationary vehicle warning is intended to be on safety, hence the emissions impacts are expected to be minimal. No effects on emissions are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider the effect on polluting emissions for this service.

**Safety**

This service is expected to work by informing drivers of slow or stationary vehicle(s) before they would be aware of the hazard without the service and may be particularly beneficial if the hazard is in an area with low visibility. This should enable drivers to have more time to prepare and navigate safely past the slow/stationary vehicle. In the DRIVE C2X study, a decrease in speed was observed for vehicles participating in the trial.

The DRIVE C2X study used accident statistics for single vehicle accidents with an object other than a pedestrian for three road types (motorways, rural roads and urban roads) to scale up the FOT results to EU level. The following assumptions were then made to scale up the potential safety impacts:

- 10-20% of accidents with an object other than a pedestrian the object would be a broken down vehicle.
- The effectiveness of car breakdown warning would vary depending on road type. The percentage of accidents prevented by road type is given below.
  - Motorways: 70-90%
  - Rural roads: 65-85%
  - Urban roads: 30-50%

Using these findings, the authors presented data in terms of the number of expected injuries and fatalities prevented (TNO et al., 2014). For the year 2030, this has been estimated to be between 12-125 fatalities and 427-2794 injuries (figures assume 76% fleet penetration). The high scenario in DRIVE C2X equates to an average **1.1% decrease in fatalities and a 0.7% decrease in injuries**.

The eIMPACT study also covered this service as part of the wireless location danger warning (one aspect of which is obstacle/stationary vehicle warning). In total, this service is estimated to have a 4.5% reduction in fatalities and a 2.8% reduction in injuries. This estimate assumes 100% penetration and the results are presented for EU-25 level. These values are much larger than those predicted by DRIVE C2X, however this is likely due to the fact that in eIMPACT, weather conditions were also considered as part of the wireless location danger warning service.

To check for agreement between the two sources, the DRIVE C2X safety impacts for slow or stationary vehicle(s) and weather warning were added together. This gave a total impact of 4.56% on fatalities and a 4.04% impact on accidents. The impact on fatalities compares well to eIMPACT data, however the combined impact on injuries for slow or stationary vehicle and weather warning predicted by DRIVE C2X is larger than that predicted by eIMPACT.

The DRIVE C2X data has been used in preference to the eIMPACT data for input into the model, as it is based on FOT data and because it provides a separate impact for slow or stationary vehicle warning, whereas eIMPACT does not.

**Other impacts**
User acceptance for the car breakdown, or slow or stationary vehicle warning was one of the highest observed during the DRIVE C2X project and was widely noted to be a very helpful feature. Drivers particularly liked the increased feeling of safety gained by reducing the surprise of encountering a slow, stationary, or broken down vehicle in the road (TNO et al., 2014).

Traffic jam ahead warning (TJW)

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

Service overview

The Traffic Jam Ahead Warning (TJW) provides an alert to the driver on approaching the tail end of a traffic jam at speed - for example if it is hidden behind a hilltop or curve. This allows the driver time to react safety to traffic jams before they might otherwise have noticed them themselves. The primary objective is to avoid rear end collisions that are caused by traffic jams on highways.

Technical information

- Day 1 V2V service
- Bundle 1

This service is applicable for all road and vehicle types, however its main benefit is expected to be on high speed roads (TEN-T Corridors, TEN-T Core and TEN-T Comprehensive network), where the system will be able to warn of traffic ahead faster than the driver is capable of identifying the danger. This service currently predominantly relies on V2V ITS-G5 communication, although a number of projects are looking to demonstrate its effectiveness using high-speed (e.g. 4G/5G) cellular networks.

Impact data

The main data source for the impacts of TJW was the DRIVE C2X project (TNO et al., 2014). An overview of the general methodology is provided in Box B-1.

For TJW, Field tests were carried out at the test sites in Spain, Italy and Germany. The test site in Germany had such a small number of traffic jams that no impacts were found. Italy also had a small number of events recorded - since real vehicle queues did not occur at all, artificial TJW events were triggered manually in high traffic density situations on motorways. Similarly, the test site in Spain had few traffic jams occurring, mainly in urban areas. Since the TJW events from Italy and Spain came from two different traffic scenarios (highway vs. urban roads respectively), it was difficult to draw a conclusion on the effectiveness from the pooled data. Nevertheless, an assessment was made using the available information and expert judgement.

In addition to DRIVE C2X, the EasyWay study considered the safety impacts of TJW (EasyWay, 2012). The EasyWay figures were based on the eIMPACT project from 2008, which scaled the values up to EU-25 level, therefore the DRIVE C2X data were used in preference. An overview of the methodology for the EasyWay project is provided in Box B-3.

Box B-3. Overview of key data source – EasyWay project

The cost-benefit analysis carried out in the EasyWay study considered the impacts of C-ITS on road safety, efficiency and congestion/traffic efficiency as well as fuel consumption and emissions. The analysis was carried out for the year 2030 and assumed 100% of all vehicles will be equipped with some form of communication device that can facilitate cooperative services. The study assumed that one third will be installed by OEMs, one third will be aftermarket devices and one third will be nomadic devices.
Primary data (for 2010) was obtained from national representatives and usually came from gathered national statistics, including:

- Vehicle fleet compositions
- Vehicle kilometres driven by road type
- Road accident statistics by severity (i.e., fatalities, injured, property damage etc.)
- Congestion (i.e., delays),
- Emissions (NO\textsubscript{x}, CO, PM2.5)
- Fuel Economy/CO\textsubscript{2} emissions for diesel and petrol cars
- Road infrastructure deployment

In cases where data was missing, the missing data was estimated by interpolating/extrapolating between countries with similar characteristics (left undefined by authors), the resulting estimates were then sent for approval form that country's representatives in the task.

To make more robust estimates for C-ITS impacts, adaptations were made to account for changes in driving behaviour and travel behaviour. These adaptations were based on simple models taken from various literature sources. The key sources were:


The data required to parametrise these models were usually taken from the same papers that presented the models. For example, for \textit{hazardous location notification}:

- It is assumed that it comprises of low friction warnings and low visibility warning. The corresponding estimated safety improvements are: 5% and 12% reductions in injury crashes, respectively; and 10% and 23% reductions in fatal crashes, respectively [Kulmala et. al. (2008) Nilsson (2004)]
- Following Kulmala et. al. (2008) and Janssen et. al. (2006), the effects of increased awareness is assumed to further reduce the risk of accidents by 11%
- Kulmala et. al. (2008), utilising the results of Janssen et. al. (2006) estimated an overall headway-related crash risk decrease of 4%
- Assuming that speed awareness and headway effects are independent (an assumption that is made for all mechanism and sub-mechanisms in adapting for behavioural changes) safety impacts for \textit{hazardous location notification} is -22% (0.915 x 0.89 x 0.96 = 0.78) for injuries and -29% (0.835 x 0.89 x 0.96 = 0.71) for fatal accidents/fatalities.

Finally, the forecasts for 2030 were estimated from the 2010 data by utilising any existing national forecasts and the forecasts provided by the eIMPACT (Wilmink et al. 2008) and CODIA projects (Kulmala et al. 2008). In addition, the general energy use and CO\textsubscript{2} forecast were taken from European Energy and Transport Trends to 2030 (published in 2007)\textsuperscript{22}. Note that for safety, the 2020 forecast was used for the 2030

Traffic efficiency and congestion

In DRIVE C2X, the traffic efficiency impacts of TJW were examined using traffic simulation, which did not show any statistically significant changes in traffic efficiency (TNO et al., 2014). This is because TJW affects how a driver approaches the tail of a traffic jam and will not affect the duration of the traffic jam. Multiple simulation runs also found that there were no second order effects impacting the characteristics of an existing traffic jam (TNO et al., 2014), and hence this impact was considered insignificant for the purposes of this study. Therefore, zero impact was assumed for this impact category in the model.

Fuel consumption and CO₂

The primary effect of TJW is intended to be on safety. Hence the fuel efficiency impacts are expected to be minimal. Minor reductions in fuel consumption could occur if a driver were able to decelerate more economically. Nevertheless, the effects are small and valid only for a short distance influenced by the traffic jam. The results from DRIVE C2X confirmed that impacts on fuel efficiency were statistically insignificant and could not be scaled up to the EU level (TNO et al., 2014).

Environmental and emissions impacts

The primary effect of TJW is intended to be on safety. Hence the environmental impacts are expected to be minimal. Minor reductions in pollutant emissions could occur if a driver were able to decelerate more economically. Nevertheless, the effects are small and valid only for a short distance influenced by the traffic jam. The results from DRIVE C2X confirmed that impacts on pollutants were statistically insignificant and could not be scaled up to the EU level (TNO et al., 2014).

Safety

The primary safety benefit provided by TJW is to avoid a rear-end collision due to ensuring earlier driver awareness of a traffic jam tail. (TNO et al., 2014). In case of high traffic flow, there might be problems of side-by-side collisions and other accident types as well if drivers carry out panic manoeuvres.

In DRIVE C2X, safety effects were presented for the EU-28 as a percentage reduction in fatalities or injuries in 2030, corresponding to various scenarios, which are based on a combination of different fleet penetration levels and the level of ambition of safety impact estimates.

Specifically, positive effects that were expected are:

- The driver will slow down earlier than without TJW.
- The driver will slow down to a lower speed than without TJW.
- The driver will not slow down earlier, but be able to react faster on approach to the traffic jam.
- The driver may also brake more smoothly when reaching the traffic jam, or to keep the lane in case of high traffic flow.

A possible rebound effect is that the driver would pay less attention to potential traffic jams due to relying on the system. However, the information provision is dependent on equipped vehicles being present to send the warning.

When the user of TJW approaches the traffic jam more smoothly, the non-users behind will most likely do so, too. The amount of fatalities and injuries in rear collisions caused by traffic jam to be prevented was assessed to be 1-5% for all driving environments due to
smoother non-user driving behaviour. The impact was assessed to be 5-10% of the impact for rear collisions to other accident types except frontal collisions.

In DRIVE C2X, FOT results were scaled up to EU-28 level based on the number of traffic jams in the EU-27. This was based on data from the Netherlands, since information for the EU was not available.

In the DRIVE C2X high scenario, the overall safety impact of TJW was calculated to be up to 193 prevented fatalities and up to 16,619 prevented injuries per year in the EU-28 in 2030. This is equivalent to a 1.7% reduction in fatalities and a 2.5% reduction in injuries.

The EasyWay project calculated the impact of the traffic jam ahead warning service on injury and fatal accidents at EU-27 level. The results from this study are shown below:

- Injury accidents and injuries: Average 2.8% reduction in injuries
  - (-4.9% on motorways, -4.1% on interurban and rural roads, and -2.0% on urban roads)
- Fatal accidents and fatalities: Average 2.4% reduction in fatalities
  - (-3.3% on motorways, -2.8% on interurban and rural roads, and -1.6% on urban roads)

These values are higher than those calculated by the DRIVE C2X report (Table B-12), however the benefits are separated by road type, as desired for the modelling. It was decided to use the DRIVE C2X data as an input to the model (given the fact that it is based on FOTs) but the impact was scaled for each road type based on the ratios from the EasyWay studies. This gave the following safety impacts:

- **Motorways**: 2.4% reduction in fatalities, 4.4% reduction in injuries
- **Other interurban roads**: 2.0% reduction in fatalities, 3.7% reduction in injuries
- **Urban roads**: 1.2% reduction in fatalities, 1.8% reduction in injuries

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<td>EasyWay</td>
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<td></td>
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<td>2.0% (urban roads)</td>
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</table>

**Other impacts**

Subjective assessment carried out in DRIVE C2X using stakeholder input suggested that TJW could help to achieve very slight decreases in stress and uncertainty, and contribute to slightly increased feelings of safety and comfort (TNO et al., 2014). The scores provided on a rating scale however fell close to the middle (i.e. a neutral impact) and therefore the effects are considered in this study to be insignificant overall. User acceptance was relatively high, with 79% of the respondents in the DRIVE C2X survey willing to use the function (TNO et al., 2014).
There were no indications of any impact on modal shift (TNO et al., 2014).

Hazardous location notification (HLN)

The 2016 C-ITS deployment study impact data presented in this section has been updated based on new data provided by the NordicWay deployment project (RicardoAEA, 2016).

Service overview

This service gives drivers an advance warning of upcoming hazardous locations in the road. Examples of these hazards include a sharp bend in the road, steep hill, pothole, obstacle, or slippery road service. Using this information, drivers will be better prepared for upcoming hazards and will be able to adjust their speed accordingly.

Technical information

- Day 1 V2V service
- Bundle 1

Hazardous locations are automatically detected by vehicles in response to changing driving behaviour or information gained from vehicle information systems. For example, a sharp bend may be detected by rapid braking and change of vehicle direction, while a pothole may be detected by a vehicle’s electronic stability control system. Information concerning the specific location and type of danger is retained and sent to vehicles in the surrounding area, warning of the hazard. This service is suitable for all vehicles and road types and may be used in combination with data gained from V2I services such as weather warning and in-vehicle signage. Whilst it is expected to rely primarily on V2V ITS-G5 communication, a number of projects are looking to demonstrate its effectiveness using high-speed (e.g. 4G/5G) cellular networks.

Impact data

The main data sources for the impacts of the hazardous location notification service are the EasyWay, eIMPACT, CODIA, NordicWay Coop and eSafetyForum Intelligent Infrastructure Working Group reports. The EasyWay and CODIA projects uses estimates from eIMPACT. An overview of the general methodology for the eSafetyForum Intelligent Infrastructure Working Group Report is provided in Box B-5, while an overview of CODIA is provided in Box B-4.
Box B-4. Overview of key data source - CODIA

The CODIA study (Co-Operative Systems Deployment Impact Assessment) aimed to evaluate the costs, impacts and benefits of five C-ITS services, namely:

- Speed adaptation due to weather conditions, obstacles or congestion (V2I)
- Reversible lanes due to traffic flow (V2I)
- Local danger / hazard warning (V2V)
- Post crash warning (V2V)
- Cooperative intersection collision warning (V2V and V2I)

The potential impacts of the selected C-ITS services were assessed up to the year 2030 and considered the entire vehicle fleet in EU-25 countries. Data was obtained from a wide range of literature sources including scientific journals, relevant EU R&D projects (in particular the COOPERS, CVIS and SAFESPOT projects) and the US DoT, For the impact assessment. The majority of vehicle, accident and traffic data was obtained from the eIMPACT project.

As many systems were not fully defined while the study was being carried out, assumptions and key findings were validated with experts from the European Commission, related European research projects, industry, and academia.

Source: (VTT, TRL, 2008)
Box B-5. Overview of key data source - eSafetyForum Intelligent Infrastructure Working Group Final Report

The eSafetyForum Intelligent Infrastructure Working Group (II WG) was formed to define Intelligent Infrastructure. The II WG aimed to answer five key questions, which are addressed in the Final Report:

- What is intelligent infrastructure?
- Which services contribute to the implementation of Intelligent Infrastructure?
- Which technological resources are necessary for these services and which business areas need to implement them?
- What needs to be done to assist/promote the implementation of these technological resources and services?
- What is the relation between Intelligent Infrastructure and Intelligent Vehicles?

As part of this report, a literature review, surveying over 20 papers was performed to assess the potential benefits and added value for a number of C-ITS services. Data for three impact categories (impact on fatalities/injuries, impact on congestion, impact on CO\textsubscript{2} emissions) were gathered for a variety of services. Services covered which are relevant to this study are: real time event information, real time traffic information, travel time information, weather information, speed limit information, parking information and guidance, local hazard warning, dynamic route guidance, emergency vehicle warning, wrong way driving warning, road user charging, requesting green/signal priorities, and intelligent truck parking.

The final report mentions a number of limitations of the values presented, noting that “figures are all based on detailed specifications of the system in question” and that “similar systems with a different technology set-up or different content quality may have largely deviating estimates of effectiveness with regard to safety, efficiency, mobility and environment”. The report stresses that local effects will be vastly different to EU scale impacts, however does not state whether the results presented are for single events, or for EU level. Further to this, penetration rates are not given for the impact data and results are not broken down by vehicle type, road type, or accident type (in the case of safety impacts).

At the time of publication (2010), few evaluation studies for cooperative systems had been performed and furthermore, the authors stated that very few quantitative estimates of the impacts have been produced. As a result, data from this study was treated with caution and was only used in the absence of any other data.

Traffic efficiency

The eSafetyForum Intelligent Infrastructure Working Group Final Report found a 2-10% reduction in congestion. The report does not specify penetration level, vehicle type or road type (eSafetyForum, 2010). Further to this, it is unclear whether this is the impact of a single event, or whether the results were scaled up to EU level (as discussed in Box B-5). The lower end of this range was therefore assumed, i.e. an impact of 2% improvement in speed across all vehicle types on urban roads.

Fuel consumption and CO\textsubscript{2}

No data was identified for this impact category in the reports reviewed. The primary effect of the hazardous location service is intended to be on safety, hence the fuel efficiency impacts are expected to be minimal. No fuel efficiency benefits are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model.

Environmental and emissions impacts

No data was identified for this impact category in the reports reviewed. The primary effect of the hazardous location service is intended to be on safety, hence the emissions impacts
are expected to be minimal. No emissions benefits are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model.

**Safety**

The safety impacts of this service were covered by several papers. The EasyWay study calculated the impact of the hazardous location service on injuries and fatalities by taking into consideration the expected change in vehicle speed (as discussed in Box B-3). The impacts were also calculated by road type, therefore this data is used in preference to those given by the eSafetyForum Intelligent Infrastructure Working Group Final Report and the CODIA study. However, correspondence with a project representative from the NordicWay Coop project suggested that the values are lower, as displayed in Table B-13. **A 30% reduction has therefore been applied to the CODIA study impact values to take into account the new NordicWay data.**

The impact on injuries and accidents calculated by EasyWay (and now scaled down by 30%) were used in the model as they build on the CODIA study and are broken down by road type. The impacts are as follows:

- Injury accidents and injuries: Average 3.1% reduction
  - This is equivalent to **-3.7% on motorways, -3.7% on interurban and rural roads, and -1.3% on urban roads**
- Fatal accidents and fatalities: Average 4.1% reduction
  - This is equivalent to **-3.6% on motorways, -3.7% on interurban and rural roads, and -1.2% on urban roads**

The eSafetyForum report (eSafetyForum, 2010) gives a value of 2-10% for the estimated reduction in fatalities/injuries. Assuming the average of this range is taken (6%), this value is significantly larger than the averages reported by EasyWay. The objective of the eSafetyForum report was to given an indication of the possible benefits, therefore the range is likely to capture all estimates, regardless of whether some data points may be outliers.

The CODIA report (VTT, TRL, 2008) also assessed the impact of local danger warnings. At 100% penetration, the authors state that a 4.2% reduction in fatalities and a 3.1% reduction in injuries is expected, provided that the system is used for all vehicle kilometres driven.

**Table B-13. Summary of safety impacts for the hazardous location service, as reported in EU C-ITS studies**

<table>
<thead>
<tr>
<th>Study</th>
<th>Fatalities (reduction)</th>
<th>Injuries (reduction)</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>EasyWay</td>
<td>4.1% (average)</td>
<td>3.1% (average)</td>
<td>100% penetration EU-27, 2030</td>
</tr>
<tr>
<td></td>
<td>5.2% (motorways)</td>
<td>5.3% (motorways)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.3% (interurban and rural roads)</td>
<td>5.3% (interurban and rural roads)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.7% (urban roads)</td>
<td>1.9% (urban roads)</td>
<td></td>
</tr>
<tr>
<td>eSafetyForum</td>
<td>2-10%</td>
<td>2-10%</td>
<td>Not stated</td>
</tr>
<tr>
<td>CODIA</td>
<td>4.2%</td>
<td>3.1%</td>
<td>100% penetration, expected impact if all vehicles were equipped, regardless of year</td>
</tr>
<tr>
<td>NordicWay</td>
<td>2.1%</td>
<td>2.5%</td>
<td>31-65% traffic flow penetration (all main roads)</td>
</tr>
</tbody>
</table>

Ref: Ricardo/ED10644/4
Other impacts

No data related to other impacts was identified in the reports reviewed.

In-vehicle signage (VSGN)

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

Service overview

In-vehicle signage is a vehicle-to-infrastructure (V2I) service that informs drivers of relevant road signs in the vehicle’s vicinity, alerting drivers to signs that they may have missed, or may not be able to see. The main purpose of this service is to provide information, give advance warning of upcoming hazards and increase driver awareness.

Technical information

- Day 1 V2I service
- Bundle 2

Via V2I communication, information about relevant road signs is provided to the driver. Roadside units may be mounted on traffic signs and key points along roads, informing drivers of potentially dangerous road conditions ahead, speed limits and upcoming junctions. Alternatively, this information may be transmitted via the local cellular network. This service is applicable to all vehicle and road types, however may have particular benefits on motorways.

Impact data

Data availability for impacts directly related to in-vehicle signage was extremely limited. The DRIVE C2X project tested six specific road signs (children, merge, pedestrian crossing ahead, pedestrian crossing, stop, yield), however trials were on a small scale and quantitative assessments of specific impacts were limited to two very specific road signs (pedestrian crossing and children sign) (TNO et al., 2014). An overview of the general methodology of DRIVE C2X is provided in Box B-1.

A report by the US Department of Transport NHTSA also estimated the impact of several road signs, however impacts were only given in terms of reduction in accidents and were not further categorised by severity.

Traffic efficiency

Although in-vehicle signage may influence traffic in a very local environment the effects are expected to be limited on an EU level, with the primary effect intended to be on safety. As in-vehicle signage is not expected to have a significant effect this impact is not included in the model. This is confirmed by the DRIVE C2X study, which did not consider the effect on traffic efficiency for this service.

Fuel consumption and CO₂

The primary effect of in-vehicle signage is intended to be on safety, hence the fuel efficiency impacts are expected to be minimal. No fuel efficiency are therefore anticipated on an EU level as a consequence of this service and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider the effect on fuel consumption for this service.

Environmental and emissions impacts

The primary effect of in-vehicle signage is intended to be on safety, hence the emissions impacts are expected to be minimal. No emissions benefits are therefore anticipated on an
EU level as a consequence of this service and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider the effect on emissions for this service.

Safety

The DRIVE C2X study estimated safety impacts based on small scale trials of only two signs: pedestrian crossing and child sign. The impact data for the high scenario is as follows:

- Impact on fatalities: 1.04% reduction
- Impact on injuries: 0.46% reduction

As DRIVE C2X only based the impacts on the pedestrian crossing and child road signs, the impacts of other types of road signs were estimated based on data from the US DoT report (John A. Volpe National Transportation Systems Center, 2008). This report estimates that a stop sign violation warning is expected to lead to a 0.088% reduction in annual light vehicle crashes. The same impact for a merge was assumed, stop and yield sign, leading to the following impacts per road type:

- Motorways:
  - Impact on fatalities: 1.04% reduction (from DRIVE C2X)
  - Impact on injuries: 0.46% reduction (from DRIVE C2X)

- Other interurban roads:
  - Impact on fatalities: 1.04% (from DRIVE C2X) + (3 x 0.088%) (applying the value of 0.088% from US DoT report for stop sign violation and assuming the same impact for merge, stop and yield signs) = **1.30% reduction in fatalities**
  - Impact on injuries: 0.46% (from DRIVE C2X) + (3 x 0.088%) (applying the value of 0.088% from US DoT report for stop sign violation and assuming the same impact for merge, stop and yield signs) = **0.72% reduction in injuries**

- Urban roads:
  - Impact on fatalities: 1.04% (from DRIVE C2X) + (3 x 0.088%) (applying the value of 0.088% from US DoT report for stop sign violation and assuming the same impact for merge, stop and yield signs) = **1.30% reduction in fatalities**
  - Impact on injuries: 0.46% (from DRIVE C2X) + (3 x 0.088%) (applying the value of 0.088% from US DoT report for stop sign violation and assuming the same impact for merge, stop and yield signs) = **0.72% reduction in injuries**

Other impacts

No data related to other impacts was identified in the reports reviewed.

*In-vehicle speed limits (VSPD)*

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

Service overview

In-vehicle speed limits are intended to prevent speeding and bring safety benefits by informing drivers of speed limits. Speed limit information may be displayed to the driver continuously, or targeted warnings may be displayed in the vicinity of road signs, or if the driver exceeds or drives slower than the speed limit.

Technical information
Roadside units at key points along roads can broadcast information to drivers about speed limits, ensuring that drivers are aware of the permitted driving speed. Alternatively this information may be transmitted via the local cellular network. This service is applicable to all vehicle and road types, however may have particular benefits when warning drivers of changing speed limits when travelling along high speed roads.

**Impact data**

The main data source for the impacts of in-vehicle speed limits was the DRIVE C2X project (TNO et al., 2014). An overview of the general methodology is provided in Box B-1. This service was trialled at test sites in Finland, Italy, Spain and Sweden in DRIVE C2X and the data was used to produce EU-level impact data reported in the DRIVE C2X impact assessment.

Other studies that considered the impacts of in-vehicle speed limits include eIMPACT, eSafetyForum Intelligent Infrastructure Working Group and SAFESPOT (TNO, VTT, Movea, PTV, BASt, 2008; eSafetyForum, 2010; SAFESPOT, 2010). DRIVE C2X refers to and builds on many of these studies; we therefore believe the DRIVE C2X study is a more reliable source of data as it is based on more recent estimates and FOT results.

**Traffic efficiency**

The primary objectives of the in-vehicle speed limit service are to decrease speed and improve safety. The increase in delay per vehicle-km found in the DRIVE C2X study (TNO et al., 2014) is therefore not surprising and can be attributed to a higher awareness of speed limits. Many traffic efficiency effects observed in the DRIVE C2X study were not statistically significant, with the only significant results being found for motorways and rural roads during off-peak times. The authors argue that this is because the impact was measured at specific point on the road (which may be subject to larger variations) rather than if speed was measured over a long stretch of road. The overall delay for different road types is shown below:

- 0.6 seconds per kilometre on motorways
- 1.1 seconds per kilometre on rural roads
- No significant effect on delay on urban roads

The eIMPACT and eSafetyForum Intelligent Infrastructure Working Group studies also considered the impact of in-vehicle speed limits on speed. The results of these studies are summarised below:

- eSafetyForum: Speed limit information 2-10% reduction in congestion.
- eIMPACT - average change in speed:
  - Motorways: 1.1% increase (low demand), 0.6% increase (high demand)
  - Rural roads: 1.0% decrease (low demand), 0.9% decrease (high demand)
  - Urban roads: 1.4% decrease (low demand), 1.7% decrease (high demand)

Change in speed was only modelled for urban roads in TRT’s ASTRA model. DRIVE C2X showed that in-vehicle speed limits did not have a statistically significant impact on urban roads, however further trials are needed to confirm this.

As an input to the model the average speed change from the eIMPACT project was therefore scaled for urban roads based on vehicle kilometres driven in high demand and low demand situations, to give an average **1.40% reduction in vehicle speed in urban areas**. The reduction was only applied to passenger cars and not to public transport.
Fuel consumption and CO₂:

Fuel consumption benefits were seen for the in-vehicle speed limits function in the DRIVE C2X study, which is likely to be due to a smoother driving style. Specifically, greater awareness of speed limits may reduce sudden acceleration and braking manoeuvres. The DRIVE C2X FOT only found a statistically significant reduction in fuel consumption on motorways and on rural roads. The DRIVE C2X study provides impact data for two scenarios:

- speed limit information shown only in the vicinity of road signs
- speed limit information displayed continuously

A much greater impact was observed when speed limit information was displayed continuously (TNO et al., 2014). In practice, speed limit information may not be displayed continuously if a variety of C-ITS services are implemented into a vehicle, therefore we have chosen to use the values for speed limit information shown only in the vicinity of road signs.

The impacts of in-vehicle speed limits were scaled up from FOT scale to EU-27 level based on the number of vehicle-kilometres travelled, in order to determine absolute fuel savings (in tonnes). We converted the figures for the high penetration level (76%) to percentages based on the share of vehicle kilometres travelled on each road type, which gave a 2.3% fuel saving on motorways and a 3.5% fuel saving on other interurban roads. These values are in the range suggested by the eSafetyForum study, which stated a 2-10% reduction in CO₂ emissions (eSafetyForum, 2010).

Environmental and emissions impacts

Minor environmental benefits were seen on motorways for the in-vehicle speed limits function in the DRIVE C2X study, which is likely to be due to a smoother driving style. Specifically, greater awareness of speed limits may reduce sudden acceleration and braking manoeuvres. However on other interurban roads, DRIVE C2X estimates a small increase in emissions, particularly PM emissions, likely due to increased braking or speed changes when approaching new speed limits. No significant effect was observed in urban areas.

The absolute emissions changes stated in DRIVE C2X for the high penetration level (76%) were converted to percentage savings on each road type, based on vehicle-kilometres driven on EU roads. The following values were inputted into the model:

- NOₓ: 0.5% reduction (motorways), 0.4% reduction (other interurban roads), zero change (urban roads)
- PM: 0.4% decrease (motorways), 4.2% increase (other interurban roads), zero change (urban roads)
- CO: 0.2% reduction (motorways), 0.2% increase (other interurban roads), zero change (urban roads)
- VOCs: 0.1% increase (motorways), 0.5% increase (other interurban roads), zero change (urban roads)

Safety

The primary function of in-vehicle speed limits is intended to be reducing speeding; an improvement in road safety is therefore expected. The DRIVE C2X study confirms this assertion and reports significant reductions in both injuries and fatalities, however the magnitude of these impacts varies depending on whether speed-limit information is shown to the driver continuously or only in the vicinity of road signs. If speed limit information is only shown in the vicinity of road signs the number of prevented fatalities is estimated to be 121-768 in 2030, whereas if information is provided continuously, an estimated 566-1772 prevented fatalities is expected. In practice, speed limit information may not be displayed continuously if a variety of C-ITS services are implemented into a vehicle, therefore the values for speed limit information shown only in the vicinity of road signs were selected for the modelling inputs.
The values for the high scenario were converted to percentages based on projected EU fatalities in 2030 (as stated in the DRIVE C2X report). This is equivalent to a \textbf{6.9\% reduction in fatalities} and a \textbf{3.9\% reduction in injuries}, applied to passenger cars and freight for all road types in the modelling.

A number of other studies covered the safety impacts of in-vehicle speed limits, as summarised in Table B-14.

\textbf{Table B-14. Summary of safety impacts of in-vehicle speed limits}

<table>
<thead>
<tr>
<th>Study</th>
<th>Fatalities (reduction)</th>
<th>Injuries (reduction)</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRIVE C2X</td>
<td>6.93%</td>
<td>3.93%</td>
<td>High penetration (100% in cars, overall 76% system penetration, high safety impact estimate) EU-28, 2030</td>
</tr>
<tr>
<td>eIMPACT</td>
<td>8.7%</td>
<td>6.2%</td>
<td>100% penetration EU-25, 2020</td>
</tr>
<tr>
<td>SAFESPOT</td>
<td>7.1%</td>
<td>4.9%</td>
<td>100% penetration EU-25, 2020</td>
</tr>
<tr>
<td>eSafetyForum</td>
<td>2-10%</td>
<td>2-10%</td>
<td>Not stated</td>
</tr>
<tr>
<td>CODIA</td>
<td>7.2%</td>
<td>4.8%</td>
<td>100% penetration for light/heavy vehicles, 55% of driven km</td>
</tr>
</tbody>
</table>

The eIMPACT project estimated an 8.7\% reduction in fatalities and a 6.2\% reduction in injuries, assuming 100\% penetration at EU-25 level. In comparison with DRIVE C2X data, the impact on both fatalities and injuries is higher.

SAFESPOT also assesses the impact of in-vehicle speed alerts and estimates a 7.1\% reduction in fatalities and a 4.9\% reduction in injuries at an EU-25 level, assuming 100\% penetration in 2020 (SAFESPOT, 2010). The estimation of impacts is based on the eIMPACT and CODIA studies and are comparable to those stated in DRIVE C2X.

The eSafetyForum study estimates a 2-10\% reduction of fatalities/injuries. The average of this (6\%) is comparable with the DRIVE C2X figure for fatalities avoided, however it is much higher than the figure for injuries. This may be because the impacts on fatalities and injuries were not treated separately as part of the eSafetyForum literature review.

CODIA estimated the effect of a service called ‘dynamic speed adaptation’ at a 100\% penetration rate. The expected reduction in fatalities was stated as 7.2\%, while the reduction in injuries was estimated to be 4.8\%. These figures are comparable to a number of studies covered here.

We have used the DRIVE C2X figures as inputs to the model as the values are based on FOT data and build on the findings of earlier EU studies in this field.

\textbf{Other impacts}

Stakeholder inputs during the DRIVE C2X project (TNO et al., 2014) suggest that user acceptance for in-vehicle speed limits is in-line with other C-ITS services. Drivers found warning messages useful when they exceeded the speed limit, however only 28\% felt that
the system provided benefits that were not provided by other functions on the market. This is likely due to satellite navigation systems providing this capability.

Qualitative effects of in-vehicle speed limits were a reported improvement in comfort and safety, however the impact on stress was questionable. Mean values for these impacts were assessed at 4.2-5.2 for comfort (on a scale from 1, strongly disagree to 7, strongly agree), and 5.2 for safety.

There were no reported impacts on modal shift.

Probe Vehicle Data (PVD)

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

Service overview

The purpose of probe vehicle data is to collect and collate vehicle data, which can then be used for a variety of applications. For example, road operators may use the data to improve traffic management.

Technical information

- Day 1 V2I service
- Bundle 2

Also known as Floating Car Data (FCD), probe vehicle data refers to the collection of data generated by vehicles. Information on a variety of vehicle parameters may be collected, including positional information, time stamp and direction of motion. Driver actions such as steering, braking, flat tyre, windscren wiper status, air bag status, as well as weather and road surface conditions can also be transmitted and collated. This probe vehicle data is used to manage traffic flows, maintain roads and to alert users in hot spots, where the danger of accidents accumulates. This service is applicable to all road and vehicle types, however may be most useful on motorways. It has the potential to deliver safety, efficiency, vehicle operation and environmental benefits. It can be delivered via the presence of roadside units to aggregate and re-transmit the data, or via the use of cellular networks.

Impact data

The main data sources for the impacts of the probe vehicle data service were the EasyWay and eIMPACT projects. To our knowledge, there are no other publically available studies that examine probe vehicle data specifically.

Traffic efficiency

In TRT’s ASTRA model, traffic efficiency impacts are only modelled on urban roads. The majority of the benefits of probe vehicle data are expected to be realised on motorways, therefore the impact of this service on traffic efficiency on urban roads was assumed to be zero.

Fuel consumption and CO2

In the CODIA study, two services called speed adaptation due to accident and speed adaptation due to poor weather were assessed. If added together, these services have similar functionality to the probe vehicle data service described in this project. CODIA estimated the impact on carbon dioxide emissions to be as follows (at 100% penetration in EU-25 countries):

- Speed adaptation due to accident: 58.5 tonnes reduction
- Speed adaptation due to poor weather: 27,682 tonnes reduction
- Speed adaptation total: 27,741 tonnes reduction (EU-25)
The carbon dioxide emissions were scaled up to EU-27 level based on vehicle kilometre data from TRT’s Astra and TRUST models, and then divided by the total EU carbon dioxide emissions stated in DRIVE C2X. This is equivalent to a **0.006% reduction in fuel consumption** in EU-27 countries.

**Environmental and emissions impacts**

Impacts on emissions were also given in the CODIA study for the dynamic speed adaptation service (includes speed limit advice given as a consequence of weather, obstacles and congestion). The results calculated in the study on an EU-25 level for a 100% penetration scenario are summarised below:

**Impact on NO\textsubscript{x} emissions:**
- Speed adaptation due to accident: 0.7 tonnes reduction
- Speed adaptation due to poor weather: 490 tonnes reduction
- Speed adaptation total: 491. tonnes reduction

**Impact on PM emissions:**
- Speed adaptation due to accident: 0.015 tonnes reduction
- Speed adaptation due to poor weather: 5.13 tonnes reduction
- Speed adaptation total: 5.12 tonnes reduction

These values are equivalent to the following percentages at EU level:

- **0.003% reduction in NO\textsubscript{x} emissions**
- **0.001% reduction in PM emissions**

As no further data was available, we have assumed the same CO reduction as for fuel consumption (assuming a linear relationship between carbon content and emissions). For VOC emissions, we have also applied the same percentage reduction as for fuel consumption (0.006%).

**Safety**

The safety impacts of probe vehicle data are primarily related to extended probe vehicle data, where the emphasis is on informing the driver about adverse road conditions ahead, for example adverse weather conditions. Safety impacts of probe vehicle data were reported in the EasyWay study (EasyWay, 2012). The following impacts were estimated (for EU-27, 100% penetration):

- Injury accidents and injuries: overall **2.8%** reduction (4.9% on motorways, 4.1% on interurban and rural roads, and 2.0% on urban roads)
- Fatal accidents and fatalities: overall **2.4%** reduction (3.3% on motorways, 2.8% on interurban and rural roads, and 1.6% on urban roads)

**Other impacts**

No data related to other impacts was identified in the reports reviewed.

**Roadworks warning (RWW)**

*The 2016 C-ITS deployment study impact data presented in this section has been updated with new data from the NordicWay deployment project* (Ricardo-AEA, 2016).

**Service overview**

Roadworks warnings enable road operators to communicate information about road works and restrictions to drivers. This allows drivers to be better prepared for upcoming roadworks and potential obstacles in the road, therefore reducing the probability of collisions.

Technical information

- Day 1 V2I service
- Bundle 2

Roadside units are mounted on road works, enabling messages and instructions to be sent to approaching drivers, either directly via ITS-G5 communications, or via the cellular network. This service is applicable to all road and vehicle types.

Impact data

The main data source for the impacts of roadworks warning was the DRIVE C2X project (TNO et al., 2014). An overview of the general methodology is provided in Box B-1. For roadworks warning, tests were carried out at test sites in Finland, Italy and Sweden. In DRIVE C2X, this service is evaluated in the same section as ‘obstacle warning’ and ‘car breakdown warning’, as the services perform a similar function, act via similar mechanisms and present information to drivers in a similar manner.

Another data source considered was the NordicWay project (Innamaa et al., 2017), which considered the safety impacts of roadworks warning, delivered by roadside systems. NordicWay deployed cooperative services via a cellular network along a corridor spanning Finland, Sweden, Denmark and Finland. ‘NordicWay Coop’ was a project along the Finnish part of the corridor that deployed safety related services. Data from this project has been examined for the roadworks warning service impacts.

To our knowledge, there are no other publically available studies that examine roadworks warning specifically.

Traffic efficiency

The traffic efficiency impacts of the roadworks warning service are expected to be minimal as its purpose is to improve safety, rather than prevent traffic jams (TNO et al., 2014). No traffic efficiency impacts are expected when scaled up to EU level and it is not included as part of the model. This is confirmed by the DRIVE C2X study, which did not consider the effect on traffic efficiency for this service.

Fuel consumption and CO₂

Fuel efficiency impacts are expected to be negligible for this service when scaled up to an EU level. This is confirmed by the DRIVE C2X study, which did not consider the effect on fuel consumption for this service.

Environmental and emissions impacts

Impacts on vehicle emissions impacts are expected to be negligible for this service when scaled up to an EU level. This is confirmed by the DRIVE C2X study, which did not consider emissions impacts for this service.

Safety

The key objective of the roadworks warning service is to improve safety, which as described in the DRIVE C2X study can be achieved by reducing the likelihood of several different types of collisions. The types of collisions expected to be prevented the most by this service are side-by-side collisions, single vehicle collisions with obstacles and rear collisions (TNO et al., 2014). Specifically, the service is expected to:

- Warn drivers about upcoming roadworks (especially those outside of the field of vision) and therefore limit unsafe manoeuvres.
- Increase driver alertness.
- Help to avoid sudden braking or steering/swerving manoeuvres.
• Reduce speed in the proximity of roadworks, thus decreasing the severity of potential injuries.

DRIVE C2X scaled up safety impacts based on Swedish road safety statistics (Liljegren, 2014), which estimate that 2.3% of injuries and 3% of fatalities occur due to roadworks. The study assumes 100% infrastructure and vehicle penetration and assumes the following:

• Roadworks warning would only be effective for accidents caused due to inattention or lack of awareness (80-90% of accidents).

• Includes winter road maintenance work which does not take place in all parts of EU28. In those countries, the number of road works may be higher overall and may be made all year round (in Nordic countries, road works only take place in the summer).

• Effectiveness of the system was estimated to be 80-90% for rear collisions, single vehicle collisions with pedestrians and other obstacles. This high level of effectiveness is due to drivers expecting these types of hazards and has been based on previous naturalistic driving studies (Dingus, 2006).

• 80-90% system effectiveness was also assumed for ‘other single vehicle accidents’. This category primarily includes driving off road during a panic manoeuvre, which would most likely be significantly reduced if roadworks warnings were operational.

• The effectiveness was estimated to be 70–80% for frontal collisions. This also represents panic manoeuvres.

• 60-70% effectiveness for other accident types. This lower effectiveness is due to the unexpected nature of these types of accident.

NordicWay also considered accidents at roadwork sites and in their influence area, which was assessed to be 1.5-2.2% of total road injury accidents. This value is taken from estimates of Danish roadwork related injury accidents (Vejdirektoratet, 2011). The following assumptions are also made:

• The main causal factor for roadworks related accidents is inattention around the critical moment/location (Innamaa et al., 2017) and it is this factor that the warning system is attempting to influence.

• In general, the impact of roadworks warning was assumed to be less than for warnings of more surprising incidents such as accidents and obstacles on the road.

• The coverage of roadworks by the warning system is assumed to be 95-100%.

• A target year of 2030 is included in the analysis, which assumed penetration across the whole main road network in Finland (31-65% of total network).

In the DRIVE C2X high scenario, the overall safety impact for this service was calculated to be 209 prevented fatalities and 9,939 prevented injuries in EU-28 countries if the service was deployed in 100% of passenger cars (equivalent to a 76% fleet penetration). This is equivalent to a 1.9% decrease in fatalities and a 1.5% decrease in injuries.

The Drive C2X values were reduced by 30%, taking into consideration the lower safety impacts reported by NordicWay Coop. An average of the two project’s values is not taken as the NordicWay values represent only a 31-65% penetration rate across Finland’s road network. Furthermore, impacts on fatal accidents were assessed based on estimates of injury related accidents occurring at roadworks, which is lower than Swedish road safety statistics estimate for fatal accidents (Liljegren, 2014).

A **1.3% decrease in fatalities** and a **1.1% decrease in injuries** were used as inputs to the model. Impacts were assumed to be the same on all road types.
Other impacts

Subjective assessment carried out during the DRIVE C2X study using stakeholder input suggested that roadworks warning has limited usefulness, however the willingness to use the service remained rather high at 79%. Further assessment suggested that the impacts of the service on stress, comfort and feelings of uncertainty were minimal. There were no reported impacts on modal shift, or a change in travel patterns in the DRIVE C2X study.

Weather conditions (WTC)

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

Service overview

The objective of this service is to increase safety through providing accurate and up-to-date local weather information. Drivers are informed about dangerous weather conditions ahead, especially where the danger is difficult to perceive visually, such as black ice or strong gusts of wind.

Technical information

- Day 1 V2I service
- Bundle 2

Vehicles are sent information from roadside units warning the driver of dangerous, or changeable weather conditions. Alternatively, the messages may be transmitted via the cellular network. This service is applicable to all roads and vehicle types.

Impact data

The main data source for the impacts of the weather conditions service was the DRIVE C2X project (TNO et al., 2014). An overview of the general methodology is provided in Box B-1. FOTs took place in Finland and Spain as part of this project, with a total of 39 participants. In Finland, slippery road warnings were presented in winter conditions, while in Spain warnings about rainy conditions were shown.

Other studies that considered the impacts include eIMPACT (TNO, VTT, Movea, PTV, BASt, 2008), CODIA (VTT, TRL, 2008), eSafetyForum (eSafetyForum, 2010), EasyWay (EasyWay, 2012), SAFESPOT (SAFESPOT, 2010) and NordicWay (Innamaa et al., 2017). Much of the safety impacts data in these projects build on and the eIMPACT study. As the DRIVE C2X project incorporates FOT results into their estimates, values from this data source were used.

Traffic efficiency

The primary effect of the weather conditions warning is intended to be on safety, hence the traffic efficiency impacts are expected to be minimal.

The DRIVE C2X study did not assess the effect of this service on traffic efficiency, citing a lack of results to be able to qualitatively evaluate the service. CODIA assessed a “local danger warning due to poor weather” service, which led to an increase of 28,489 thousand hours on the road per year in EU25 at a 100% penetration rate. When converted to a percentage, the effect on time spent on the road is less than 0.1%, applied to both cars and public transport on all road types in the modelling.

Another service, ‘speed adaptation due to poor weather’ was also separately assessed in CODIA. The impacts associated with this service have not been included in this study as the service definition for weather warning does not state that speed limit information will be provided to the driver.

Fuel consumption and CO₂
The primary effect of the weather conditions warning is intended to be on safety, hence the fuel consumption impacts are expected to be minimal on an EU level. The DRIVE C2X study did not assess the effect of this service on fuel consumption, however CODIA assessed a service called ‘local danger warning due to poor weather’. At a 100% penetration level, a 47,407 tonnes per year reduction in carbon emissions at EU-25 level was calculated (VTT, TRL, 2008). This was scaled to EU-27 level based on vehicle kilometre data from TRT’s TRUST and Astra models. The resulting value (48,444) was divided by the total annual EU CO₂ emissions stated in DRIVE C2X. This gives a 0.005% reduction in fuel consumption at an EU-27 level, which was applied to both cars and public transport on all road types in the modelling.

Environmental and emissions impacts

Minor emissions benefits for the ‘local danger warning due to poor weather’ service were reported in CODIA. At a 100% penetration level, the following impacts on emissions were calculated by CODIA (VTT, TRL, 2008):

- 752.50 tonnes per year reduction in NOₓ emissions at EU25 level
- 9.15 tonnes per year reduction in particulate matter emissions at EU25 level

These values are equivalent to the following percentages at EU level:

- 0.02% reduction in NOₓ emissions
- 0.01% reduction in PM emissions

As further data was not available, we have assumed the same CO reduction as for fuel consumption (assuming a linear relationship between carbon content and emissions). For VOC emissions, we have also applied the same percentage reduction as for fuel consumption. These values were applied to cars and freight vehicles on all road types in the modelling.

Safety

The objective of this service is to increase safety in adverse weather conditions such as ice, fog, rain, snow, sleet, hail and wind. The main impacts are expected to occur via direct in-vehicle modification of the driving task after drivers receive information about adverse weather conditions. Specifically, this service is expected to have a number of impacts:

- In conditions where the danger can easily be perceived (such as heavy rain), the notification serves as a reminder of the potential danger ahead, and increasing driver awareness.
- In situations where the danger cannot be easily be perceived (such as strong cross-winds, or black ice) drivers will receive valuable information regarding local weather conditions/hazards that they otherwise would not have known about.
- In both of the above situations, the driver will be more prepared for the hazard and will have the opportunity to adjust their speed accordingly, preventing sudden braking, accelerating, swerving or overtaking manoeuvres.

It is thought that any rebound effects from over-reliance on the system will be negligible. This is because the information used to deliver the service will come partially from other vehicles further ahead and therefore drivers cannot assume that there will always be suitably-equipped vehicles ahead (TNO et al., 2014).

DRIVE C2X scaled up safety impacts based on the impact on driver speeds, driver awareness and the headway between vehicles, using values from FOT data, expert estimates and estimates from the CODIA and eIMPACT projects. For the high scenario in 2030, this resulted in a projected 3.43% reduction in fatalities and a 3.35% reduction in injuries, applied to cars and freight on all road types in the modelling. These values are supported by those reported in the NordicWay project.

Potential safety impacts of the weather conditions service are covered in many other studies, as summarised in Table B-15. The values from DRIVE C2X are used as an input to
the modelling in this project as they are based on FOT data and build on previous EU studies. A discussion of results from other studies is provided below for comparison.

**Table B-15. Summary of safety impacts of weather conditions services from EU studies**

<table>
<thead>
<tr>
<th>Study</th>
<th>Fatalities (reduction)</th>
<th>Injuries (reduction)</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRIVE C2X</td>
<td>3.43%</td>
<td>3.35%</td>
<td>76% penetration, high safety impact estimate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EU-28, 2030</td>
</tr>
<tr>
<td>NordicWay</td>
<td>3.5%</td>
<td>3.9%</td>
<td>100% penetration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Finland, 2030</td>
</tr>
<tr>
<td>EasyWay</td>
<td>16.5% (average)</td>
<td>8.5% (average)</td>
<td>100% penetration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EU-27, 2030</td>
</tr>
<tr>
<td>eIMPACT</td>
<td>4.5%</td>
<td>2.8%</td>
<td>100% penetration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EU-25, 2020</td>
</tr>
<tr>
<td>SAFESPOT</td>
<td>1.6% (V2I)</td>
<td>0.7% (V2I)</td>
<td>100% penetration</td>
</tr>
<tr>
<td></td>
<td>16.4% (V2V)</td>
<td>8.6% (V2V)</td>
<td>100% penetration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EU-25, 2020</td>
</tr>
<tr>
<td>eSafetyForum</td>
<td>2-4%</td>
<td>2-4%</td>
<td>Not stated</td>
</tr>
</tbody>
</table>

Estimations in the EasyWay project are based on the methodology from the CODIA project and state that if the base speed is 80km/h, there will be a 5% decrease in injury crash risk in adverse conditions, if low friction warnings are displayed, while a 12% decrease in injury collisions is expected for a fog warning. For a fatal crash risk, the percentage reductions are 10% for low friction warning and 23% for fog warnings. EasyWay averaged these figures to give overall impacts of 8.5% on injury crashes and 16.5% on fatal crashes.

eIMPACT evaluated a service called wireless location danger warning, one aspect of which is weather warning. A 4.5% reduction in fatalities and a 2.8% reduction in injuries was estimated, assuming 100% penetration on an EU-25 level. These values are slightly higher than those estimated by DRIVE C2X, however this is likely to be because eIMPACT also considered stationary vehicle warning to be part of this service.

SAFESPOT assesses the impact of two weather warning services: road departure (V2V) and hazard and incident warning (V2I). The road departure (V2V) use case informs the drivers of road conditions, such as a slippery road. SAFESPOT estimates an 8.6% reduction in injuries and a 16.4% reduction in fatalities, which is based on values obtained from the eIMPACT and CODIA projects. These figures are almost identical to EasyWay. The hazard and incident warning (V2I) use case includes weather conditions that result in reduced friction on the road or reduced visibility, such as ice, rain or fog and was shown to be significantly less effective than the V2V service. The estimation of impacts are again based on the eIMPACT and CODIA studies. SAFESPOT estimates a 1.6% reduction in fatalities and a 0.7% reduction in injuries at an EU-25 level, assuming 100% penetration in 2020 (SAFESPOT, 2010). These values are slightly lower than other reports reviewed in this section.

Finally, eSafetyForum reported that a weather conditions service could lead to a 2-4% reduction of fatalities/injuries. This is consistent with the DRIVE C2X figures.

**Other impacts**

A survey of drivers in the DRIVE C2X study indicated that 76% of drivers agreed that the weather conditions warning was useful, which is lower than the average for all services.
tested. This is likely due to the fact that drivers were more enthusiastic about particular types of weather warnings than others. For example, qualitative feedback provided by test drivers showed they were particularly receptive to warnings about potentially more serious hazards such as ice on the road, however they were less enthusiastic about receiving repetitive rainy conditions warnings while driving along a straight road. User acceptance is therefore likely to be dependent on the type of weather warning and how drivers value each type of weather warnings.

Further assessment showed that test drivers felt an increased sense of safety and comfort as a result of this service. On a scale of 1 (strongly disagree) to 7 (strongly agree), the mean value for increased feeling of comfort was 4.8 and for safety was 5.5.

There were no reported impacts on modal shift, or a change in travel patterns in the DRIVE C2X study.

**Shockwave damping (SWD)**

*The impact data presented in this section are from the 2016 C-ITS deployment study.* (Ricardo-AEA, 2016).

**Service overview**

Shock wave damping aims to smooth the flow of traffic, by damping traffic shock waves.

**Technical information**

- Day 1 V2I service
- Bundle 2

Real-time traffic data is used to feed advisory speeds to cars to smooth out speed variations. This service is applicable to all vehicle types and is particularly relevant to motorways. Again, it could be delivered via roadside units, or the cellular network.

**Impact data**

The main data source for the impacts of shockwave damping was the CODIA project (VTT, TRL, 2008). To our knowledge, there are no other publically available studies that specifically examine this service. The majority of the benefits of shockwave damping are expected to be on motorways, therefore the impact of this service on urban roads and other interurban roads is assumed to be zero.

**Traffic efficiency**

CODIA assessed a dynamic speed adaptation due to congestion service that closely matches our definition of the shockwave damping service. As a consequence of this service, the authors estimated an increase of time spent on the road of 63.5 thousand vehicle hours per year in EU25 at 100% penetration rate. In TRT’s ASTRA model, traffic efficiency impacts are only modelled on urban roads. This service is not expected to have an impact on urban roads, therefore the impact on traffic efficiency was assumed to be zero.

**Fuel consumption and CO2**

The dynamic speed adaptation due to congestion service assessed in CODIA estimates a reduction of 26,232 tonnes per year of carbon emissions at EU-25 level in a 100% penetration scenario (VTT, TRL, 2008). When calculated as a percentage, these effects are extremely small (*0.005% reduction*). It is assumed that all fuel consumption benefits will occur on motorways and that there will be zero impact on fuel consumption on other interurban roads, and urban roads.

**Environmental and emissions impacts**

The dynamic speed adaptation due to congestion service assessed in CODIA calculated the following impacts on vehicle emissions if the service is deployed at a 100% penetration level in EU-25 countries (VTT, TRL, 2008):
• 363 tonnes per year reduction in NO\textsubscript{x} emissions at EU25 level

• 6.0 tonnes per year reduction in particulate matter emissions at EU25 level

When calculated as a percentage, these effects are extremely small (less than 0.1%).

Safety

One of the primary objectives of this service is to improve safety on high-speed roads. In CODIA, estimates of safety impacts were presented for the dynamic speed adaptation due to congestion/obstacles at a 100% penetration level (VTT, TRL, 2008). The study estimates a 13% reduction in fatalities and a 10.3% reduction in injuries on motorways.

The inclusion of obstacle warnings in the CODIA definition results in additional functionality to the shockwave damping service defined in this study, therefore the safety impacts of the hazardous location service were subtracted from the figures reported in CODIA. This gave the following values, which were used in the modelling:

• Reduction in fatalities on motorways: 7.8%

• Reduction in injuries on motorways: 5.0%

Other impacts

No data related to other impacts was identified in the reports reviewed.

**Green Light Optimal Speed Advisory (GLOSA) / Time to Green (TTG)**

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

**Service overview**

GLOSA provides speed advice to drivers approaching traffic lights, reducing the likelihood that they will have to stop at a red light, and reducing the number of sudden acceleration or braking incidents. This is intended to provide traffic efficiency, vehicle operation (fuel saving) and environmental benefits by reducing unnecessary acceleration.

**Technical information**

- Day 1 V2I service
- Bundle 3

Traffic lights are connected to a roadside unit, which broadcasts information to nearby vehicles informing them of the traffic light phase schedule. This will enable vehicles to calculate optimal speed of approach. Time to green information may also be presented to drivers. It is applicable to all vehicle types and is particularly suitable in urban areas, where intersections are generally sited. Whilst it is expected to rely primarily on V2I ITS-G5 communication, a number of projects are looking to demonstrate its effectiveness using high-speed (e.g. 4G/5G) cellular networks.

**Impact data**

The main data source for the impacts of GLOSA was the DRIVE C2X project (TNO et al., 2014). An overview of the general methodology is provided in Box B-1. For GLOSA, tests were carried out at test sites in Germany, Spain and Sweden. However, the number of events available after filtering in Sweden was too low to provide a good comparison of with and without-service behaviour. Similarly, the data from the Spanish test site was interpreted as a first order effect rather than an effect of GLOSA. Hence, pooling the GLOSA data was not straightforward due to the large differences in experimental set-up.

Other studies that considered the impacts include the Dutch ODYSYA project and subsequent follow-ons; Beek et al. 2013 and van Katwijk et al. These studies were taken into account in the DRIVE C2X results and hence were not considered further here.

Ref: Ricardo/ED10644/4
Traffic efficiency

In DRIVE C2X, traffic efficiency was assessed by naturalistic driving tests on urban roads and by simulations. The results were dependent on the level of traffic, with tests showing a slight overall increase in delay per traffic light, which was attributed to the slower speed of approach. The time spent stationary at traffic lights may be reduced by this service but the effects are not statistically significant. Results from the test site in Germany indicated that driver behaviour may become smoother and results from the literature surveyed by the authors of DRIVE C2X are inconclusive. The DRIVE C2X study team fed FOT data into a model, in order to calculate impacts. They reported an unexpected result of a 9% increase in delay for the implementation of GLOSA, however this was probably due to the way the yellow light was simulated in the model.

Overall, the effects on traffic efficiency are assumed to be small because (1) the system is not necessary when the driver arrives at a light that is already green; and (2) GLOSA has limited potential to affect the possibility of a driver arriving at a red light.

As the results currently stated in the literature are inconclusive, it is assumed that this service will not have an impact on traffic efficiency in urban areas.

Fuel consumption and CO$_2$

The primary effect of GLOSA is expected to be on fuel efficiency and environmental impacts due to reduced braking and acceleration while passing through traffic lights. The DRIVE C2X study shows that impacts are dependent on vehicle technology, with hybrids showing lower potential for improvement. The impact on motorways is assumed to be negligible, since GLOSA is only effective at traffic light controlled intersections. The study reported the following specific effects on urban roads, in the high penetration scenario:

- A reduction in fuel consumption of 3% when approaching an intersection. The authors scaled this impact to EU-27 level based on the number of approaching vehicles at signalised intersections in EU-27 countries. The number of approaching vehicles per year at signalised intersections in the EU-27 was estimated to be 1.708 trillion, concentrated on rural and urban roads (estimated to be 70% for urban and 30% for rural), as shown in Table B-16. Although the amount of signalised intersections was known at the EU level, the number of approaching vehicles was estimated based on data from the Netherlands, as information for the EU was not available.

Table B-16. Estimation of the number of vehicles approaching intersections in EU-27 countries per year (Source: DRIVE C2X)

<table>
<thead>
<tr>
<th>Road type</th>
<th>Low demand (billions)</th>
<th>High demand (billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High speed roads</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rural roads</td>
<td>358.7</td>
<td>153.7</td>
</tr>
<tr>
<td>Urban roads</td>
<td>837.0</td>
<td>358.7</td>
</tr>
</tbody>
</table>

- An overall reduction in fuel consumption of 219,729 tonnes on rural roads and 512,702 on urban roads when scaled up to EU-27 level.
- This is equivalent to a **0.1% reduction in fuel consumption on rural roads and a 0.7% reduction in fuel consumption on urban roads**.

The DRIVE C2X values are lower than an earlier TNO study which estimated that traffic signal optimisation could lead to a 2% reduction in CO$_2$ emissions on an EU-27 level. We have opted to use the DRIVE C2X figures in the modelling as they are based on FOT data.

Environmental and emissions impacts

Only the DRIVE C2X study presented detailed results about the impact of GLOSA on vehicle emissions. Per intersection approach, the following effects were observed:
• Reductions in CO and HC emissions of 15.5% and 40.2%. The levels of changes to these pollutants are large because they are highly sensitive to acceleration and braking.

• Reduction in NOx emissions of 3.2%

The authors scaled these figures up to EU-27 level by road type to give the impact on each pollutant in tonnes per year. These absolute emissions reductions were converted to percentages based on the annual pollutant emissions by road type from TRT’s ASTRA and TRUST models. The following inputs were used in the model:

- **CO**: 0.3% reduction (other interurban roads), 0.8% (urban roads)
- **NOx**: 0.1% reduction (other interurban roads), 0.2% (urban roads)
- **VOCs**: 0.5% reduction (other interurban roads), 0.6% (urban roads)
- **PM**: 0.1% reduction (other interurban roads), 0.0% (urban roads)

**Safety**

GLOSA was found to have minor safety benefits in the DRIVE C2X study (TNO et al., 2014), mainly as a consequence of the lower number of vehicles needing to stop at traffic lights. Since the primary objective of GLOSA is not safety-related, it is to be expected that the overall impacts are small.

Specifically, positive effects that were expected are:

- On average, drivers will need to stop at traffic lights less with GLOSA. The probability of a rear-end collision is therefore reduced.
- Smoother driving behaviour is expected on the approach to traffic lights, reducing both the risk and severity of a collision.
- Drivers will, on average, approach traffic lights at a lower speed with GLOSA.
- Abrupt and indecisive braking behaviour will be eliminated due to the information GLOSA provides to drivers. This will reduce the risk and impact of rear-end crashes, limit red light violations and reduce angle-crashes.

However, the study also suggests that GLOSA may be less effective and less reliable for adaptive or actuated traffic lights, as these are dependent on unpredictable traffic flows. The service may also distract drivers, resulting in decreased attention on the road ahead, due to focussing on the in-vehicle advisory system. This is expected to be minor and may be limited further by good design on the in-vehicle interface.

The effectiveness of GLOSA was found to be highly dependent on penetration rate and traffic intensity. Safety effects were presented as a percentage reduction in fatalities or injuries in 2030 for 100% infrastructure penetration. In the high scenario in 2030, the average fatalities prevented was estimated to be 0.1% on both urban and rural roads, while the average number of injuries prevented was estimated to be 0.1% on rural roads and 0.3% on urban roads.

**Other impacts**

Stakeholder inputs during the DRIVE C2X project suggest that user acceptance for GLOSA is very high, with 86% of drivers rating the service as useful, while 50% claimed they would be willing to pay for use of the feature if it was available in their vehicle (TNO et al., 2014).

Qualitative effects of GLOSA were reported as improvements in terms of decreased stress and uncertainty, and an increased feeling of safety and comfort. The typical mean agreement values for comfort were 4.9–5.6 (on a scale from 1, strongly disagree to 7, strongly agree), for safety approximately 4.8 and for stress 4.7–5.2. Stress and uncertainty were also assessed on a scale from -3 to 3 (decrease-increase), and the typical mean values for those scales were approximately -0.5 for stress and from -1.0 to -0.2 for uncertainty.
There were no reported impacts on modal shift.

**Signal violation/Intersection safety (SigV)**

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

**Service overview**

The primary objective of this service is to reduce the number and severity of collisions at signalised intersections.

**Technical information**

- Day 1 V2I service
- Bundle 3

This service, also known as the Red Light Violation Warning (RLVW), allows for drivers to be warned when they are in danger of violating a red light, or when it is probable that another vehicle is going to make a red light violation. It is applicable to all vehicle types and is particularly suitable in urban areas, where intersections are generally sited.

**Impact data**

The main data sources for the impacts of signal violation/intersection safety were the eIMPACT project (TNO, VTT, Movea, PTV, BASt, 2008) and SAFESPOT study. An overview of the general methodology for the eIMPACT study is provided in Box B-2.

**Traffic efficiency**

The SAFESPOT study assumes that no traffic impacts are experienced but refers to the statement in the eIMPACT study that traffic effects are expected but have not been proven (SAFESPOT, 2010). As no quantitative estimates have been given in the literature, it is assumed that this service will not have an impact on traffic efficiency.

**Fuel consumption and CO₂**

No data was identified for this impact category in the reports reviewed. Fuel consumption impacts for this service are assumed to be zero.

**Environmental and emissions impacts**

No data was identified for this impact category in the reports reviewed. Impacts on vehicle emissions for this service are assumed to be zero.

**Safety**

The primary objective of this service is to improve safety at traffic intersections. A review of the reports covering this service revealed that the intersection safety service is defined differently depending on the study, with some studies including additional functionality such as GLOSA. A summary of the safety impacts stated in the studies reviewed is given in Table B-17.

**Table B-17. Summary of safety impacts of the intersection safety service reported in other European studies**

<table>
<thead>
<tr>
<th>Study</th>
<th>Fatalities (reduction)</th>
<th>Injuries (reduction)</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>eIMPACT</td>
<td>3.9% (includes GLOSA / TTG)</td>
<td>7.3% (includes GLOSA / TTG)</td>
<td>100% penetration EU-25, 2020</td>
</tr>
</tbody>
</table>
The eIMPACT study states 3.9% reduction in fatalities, 7.3% reduction in injuries, assuming 100% penetration in at EU-25 level in 2020. GLOSA/TTG functionality is also included in the eIMPACT definition of this service. If the safety impacts of GLOSA (the high scenario in the DRIVE C2X study estimates a 0.1% reduction in fatalities and a 0.3% reduction injuries) are subtracted from the impact predicted by eIMPACT, the impact would be a 3.8% reduction in fatalities and a 7.0% reduction in injuries. These are very similar to those suggested by CODIA (VTT, TRL, 2008).

The SAFESPOT study evaluated two intersection safety functions. The first function, a V2V service called “lateral collision – road intersection safety” assessed the impact of in-vehicle left-turn assistance (SAFESPOT, 2010). Assuming 100% penetration in the EU-25 in 2020, the estimated impact of this service is a 0.7% reduction in fatalities and a 2.2% reduction in injuries. These results are based on the PReVAL project, which follows the same methodological approach implemented by the eIMPACT study. Another intersection safety function evaluated by SAFESPOT was the “Intelligent Cooperative Intersection Safety system – IRIS” service, which is based on V2I communication. This service primarily aims to prevent red light violations, although also includes left and right turn assistance. The estimated impact of this service, assuming 100% penetration, is a 3.1% reduction in fatalities and a 4.8% reduction in injuries at EU-25 level (SAFESPOT, 2010). These results are based on the findings of the eIMPACT and CODIA projects. If the impacts of the two SAFESPOT intersection safety services are added together, a 3.8% reduction in fatalities and a 7.0% reduction in injuries is found.

The CODIA study also assessed the impact of cooperative intersection collision warning. This report estimated a 3.7% reduction in fatalities and a 6.9% reduction in injuries at a 100% penetration rate, providing the system is used in all intersections in the EU (VTT, TRL, 2008).

Based on the above, the most appropriate figure was selected as the eIMPACT estimation (with GLOSA impacts subtracted). A **3.8% reduction in fatalities and a 7.0% reduction in injuries on urban roads, and other interurban roads** were used as inputs to the modelling. These percentages were applied to **all vehicle types** and are very similar to those stated by the SAFESPOT and CODIA studies.

### Other impacts

No data related to other impacts was identified in the reports reviewed.

#### Traffic signal priority request by designated vehicles (TSP)

The impact data presented in this section are from the **2016 C-ITS deployment study**. (Ricardo-AEA, 2016).

### Service overview
The traffic signal priority request by designated vehicles allows drivers of priority vehicles (for example emergency vehicles, public transport, HGVs) to be given priority at signalised junctions.

**Technical information**

- Day 1 V2I service
- Bundle 3

This service works by either extending or terminating the current traffic light phase, to ensure that the required phase is displayed. Different levels of priority can be applied, depending on the vehicle type. For example, emergency vehicles may be given the highest priority, whereas the appropriate level of green priority for a public transport vehicle may be dependent on its current status, i.e. whether it is on-time or behind schedule. This has the potential to deliver a variety of benefits. Safety benefits may be gained by extending the phase for emergency vehicles travelling at speed, efficiency benefits for public transport and environmental benefits gained when reducing the need for vehicles to repeatedly brake and accelerate through signalised intersections. This service is most suitable for urban environments and is applicable for all vehicle types except passenger cars. Whilst it is expected to rely primarily on V2I ITS-G5 communication, a number of projects are looking to demonstrate its effectiveness using high-speed (e.g. 4G/5G) cellular networks.

**Impact data**

The main data sources for the impacts of the traffic signal priority request by designated vehicles service were the eSafetyForum Intelligent Infrastructure Working Group’s Final Report and the COMeSafety project. An overview of the general methodology of the eSafetyForum report is provided in Box B-5.

To our knowledge, despite several European FOTs trialling this service, there are no other publically available studies that specifically examine traffic signal priority request by designated vehicles as a C-ITS service.

The limited information from the above two reports was therefore supplemented by additional desk research into traffic signal priority systems – this yielded one particularly useful source of information, namely a study by the UITP Working Group (TfL, TRL, University of Southampton, 2009) on the interaction of buses and signals at road crossings. This study analysed a number of European city bus priority projects, summarising travel time reduction data for buses equipped with a variety of bus priority systems allowing them to interact with traffic lights to smooth their passage through signalised intersections. One such example is the SCOOT system currently being trialled by Transport for London. Whilst not using the ITS-G5 protocols discussed in this study, some of the systems discussed in this study could loosely fall within the definition of C-ITS services and operate through very similar mechanisms to the C-ITS service discussed here. It was therefore deemed appropriate to use input data from this study to estimate impacts data from first principles.

**Traffic efficiency**

Traffic signal priority request will only be available to certain vehicles on other interurban roads and urban roads. For the purposes of the modelling, it is assumed that this service will only apply to public transport and not passenger cars or freight vehicles. In most situations, there will also be secondary effects on non-bus users. This is captured in the modal shift element of TRT’s ASTRA model.

The eSafetyForum literature review suggests that requesting green/signal priorities can lead to a 1-2% reduction in congestion, however this cannot be easily translated into an impact on urban travel speed, which is the required input for the modelling.

In the absence of data from specific C-ITS studies, data from the UITP Working Group report was therefore used as an input to the model. Quantitative estimates of travel time...
savings for bus priority systems were given for trials in the following cities: Aalborg, Cardiff, Genoa, Gothenburg, Helsinki, Prague, Stockholm, Stuttgart, Toulouse and Turin. The average saving was a 9.2% reduction in travel time for buses equipped with some form of traffic signal priority system.

**Fuel consumption and CO₂**

Reduced fuel consumption is one of the main objectives of this service. The eSafetyForum report suggests that requesting green/signal priorities can lead to a 1-3% impact reduction in carbon dioxide emissions, while results of the FREILOT project show that HGVs equipped with this service reported reductions in fuel consumption of up to 20% (CRF, BASf, ERTICO, VOLVO, Hess-Consult, BMW, 2014). The FREILOT project was a FOT based on 11 intersections, with 7 trucks equipped with a number of services, including traffic signal priority, energy efficient driving (which provided speed advice and indicated when to shift up or down in order to save energy) and remote parking spot booking for loading and unloading. However given the lack of references in the eSafetyForum output and the difficulty in separating traffic signal priority from other services in the FREILOT project, it was decided to estimate fuel consumption and CO₂ savings using the results of the UITP Working Group study referenced above.

To this end, the average speed of buses without any traffic signal priority service installed was estimated from the UITP Working Group study at 15.3 kph, alongside the improved speed (9.2% reduction in time spent travelling) of 17.2 kph. This difference in speed was used as an input to Ricardo Energy and Environment’s speed-emissions curve model, which is able to estimate the impact on CO₂/fuel consumption, NOₓ and PM₁₀ emissions.

The total improvement in fuel consumption and CO₂ emissions was therefore estimated as **8.28% across all buses in urban environments**.

**Environmental and emissions impacts**

NOₓ and PM emissions were estimated using the same speed-emissions curve model as for fuel consumption/CO₂. Total improvement in NOₓ and PM emissions were estimated at **8.04% and 8.17% respectively across all buses in urban environments**.

For **CO and VOC emissions**, these were assumed to be proportional to fuel consumption savings, and therefore estimated at an **8.28% reduction for urban buses**.

**Safety**

No data was identified for this impact category in the reports reviewed and given that this service will most likely only be available to a limited number of vehicles, it is assumed that the impact on safety at an EU-level will be negligible for this service and it is not included in the model.

**Other impacts**

No data related to other impacts was identified in the reports reviewed.

**On street parking information and management (Pinfo)**

*The impact data presented in this section are from the 2016 C-ITS deployment study.* (Ricardo-AEA, 2016).

**Service overview**

The provision of on-street parking information is intended to bring efficiency benefits to drivers and help to reduce emissions in urban areas by reducing the time spent ‘cruising’ at low speeds.

**Technical information**

- Day 1.5 V2I service
- Bundle 4
Parking space availability is provided to interested vehicles, decreasing the amount of time spent searching for a safe, and appropriate place to park. This service is anticipated to be most applicable for urban roads, where on-street parking space availability is often limited and therefore in high demand. It is applicable for all vehicle types except public transport but will be most useful for drivers of cars. As for off street parking information, this service may include the functionality to book parking spaces in advance.

**Impact data**

The only data source which covered the potential impacts of the on street parking information service was the eSafetyForum Intelligent Infrastructure Working Group’s Final Report. An overview of the general methodology of the eSafetyForum report is provided in Box B-5.

The information from this report was supplemented by additional desk research into the provision of parking information services and the time spent searching for parking spaces. A number of reports were used to estimate the impact of this service from first principles, as referenced below.

**Traffic efficiency**

Traffic efficiency improvements are expected to be the main benefit of this service. No data was identified for this impact category in the reports reviewed. The following methodology was therefore used to estimate impacts on traffic efficiency from first principles:

- Identify the time spent looking for a parking space in a Member State.
  - In France, an estimated 70 million hours per year is spent ‘cruising’ trying to find parking (Gantelet & Lefauconnier, 2006).
- Scale this to EU level, based on total vehicle kilometres driven in urban areas (based on data for the EU-27 from TRT’s ASTRA model).
  - Gives an estimated 450,272,549 hours ‘cruising’ per year for the EU
- Apply an effectiveness factor to the parking information C-ITS service.
  - 3.5 times less time spent cruising for parking to final destination when parking information is shown (or a 71% effectiveness), according to a report published by the University of Zurich (Tsiaras, et al., 2015).
- Use this number to estimate the total change in time spent driving on urban roads from deploying parking information services to all vehicles at an EU level.
  - 0.61% reduction in travel time/improvement in speed in urban areas across passenger and freight vehicles.

**Fuel consumption and CO₂**

The average speed of vehicles when ‘cruising’ for parking spaces in urban areas was estimated at half the average speed limit for urban areas (Tsiaras, et al., 2015), i.e. 15 kph in the EU.

This speed was used as an input to Ricardo Energy and Environment’s speed-emissions curve model, which is able to estimate the impact in g/km on CO₂/fuel consumption, NOₓ and PM₁₀ emissions. Using the total time spent ‘cruising’ and average speed of ‘cruising’ referenced above, a total EU-level cruising distance could be determined, from which the total EU-level emissions impacts could be estimated.

The total resultant **improvement in fuel consumption and CO₂ emissions** was estimated from the above methodology as **0.79% across passenger and freight vehicles in urban environments.**

**Environmental and emissions impacts**

NOₓ and PM emissions were estimated using the same speed-emissions curve model as for fuel consumption/CO₂. Total improvement in **NOₓ and PM emissions** were estimated at
0.26% and 0.07% respectively across all passenger and freight vehicles in urban environments.

For CO and VOC emissions, these were assumed to be proportional to fuel consumption savings, and therefore estimated at a 0.79% reduction for urban passenger and freight vehicles.

Safety
The eSafetyForum reports that parking information and guidance will have zero impact on safety. Whilst there may be secondary impacts due to reduced congestion in urban areas, no data exists to support this and the safety impacts were therefore assumed to be zero.

Other impacts
No data related to other impacts was identified in the reports reviewed.

Off street parking information and management (PMang)

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

Service overview
The provision of on-street parking information is intended to bring efficiency benefits to drivers and help to reduce emissions in urban areas by reducing the time spent ‘cruising’ at low speeds.

Technical information

- Day 1.5 V2I service
- Bundle 4

Parking space availability is provided to interested vehicles, decreasing the amount of time spent searching for a safe and appropriate place to park. This service is applicable for all road types and all vehicle types except for public transport. It may be particularly useful for long-distance HGV drivers. In the future, this service may include advance booking capability. This will deliver efficiency and environmental benefits.

Impact data
To our knowledge, there are no other publically available studies that specifically examine off street parking information. Impacts for off street parking were assumed to be similar to on street parking, therefore the same values have been used as inputs to the modelling.

Traffic efficiency
No data was identified for this impact category in the reports reviewed, therefore the same value as for on street parking was used: a 0.61% reduction in travel time/improvement in speed in urban areas across passenger and freight vehicles was used as the modelling input.

Fuel consumption and CO₂
No data was identified for this impact category in the reports reviewed, therefore the same value as for on street parking was used: a 0.79% reduction in fuel consumption/CO₂ in urban areas across passenger and freight vehicles was used as an input to the modelling.

Environmental and emissions impacts
No data was identified for this impact category in the reports reviewed, therefore the same values as for on street parking were used as inputs to the modelling. These are summarised below:
• **NOx**: 0.26% reduction in urban areas across passenger and freight vehicles
• **PM**: 0.07% reduction in urban areas across passenger and freight vehicles
• **CO**: 0.79% reduction in urban areas across passenger and freight vehicles
• **VOC**: 0.79% reduction in urban areas across passenger and freight vehicles

**Safety**

The eSafetyForum Intelligent Infrastructure Working Group Report suggested that parking information services will have zero impact on safety. Whilst there may be secondary impacts due to reduced congestion in urban areas, no data exists to support this and the safety impacts were therefore assumed to be zero.

**Other impacts**

No data related to other impacts was identified in the reports reviewed.

**Park & Ride information (P&Ride)**

_The impact data presented in this section are from the 2016 C-ITS deployment study._ (Ricardo-AEA, 2016).

**Service overview**

The provision of Park & Ride information is intended to reduce congestion in urban areas and also shift travel from cars to public transport.

**Technical information**

- Day 1.5 V2I service
- Bundle 4

In combination with other parking information services, this will allow drivers to determine the most suitable parking option, while also allowing maximum utilisation from the perspective of the operator. This improves overall network efficiency and can deliver efficiency and environmental benefits. This service is applicable to all road types and is most applicable to personal transport.

**Impact data**

To our knowledge, there are no other publically available studies that specifically examine the impacts of this service.

**Traffic efficiency**

Park and ride schemes are designed to reduce congestion in urban areas, therefore some traffic efficiency impacts are to be expected. However, these urban efficiency gains do not occur directly with the vehicle using the service, since the impact of the service will be to increase the likelihood of the vehicle in question using Park & Ride services – thereby preventing it entering the congested urban area. This makes it very difficult to estimate the impact on efficiency from first principles. In the absence of any data for this impact category in the reports reviewed, it was assumed that the service would have zero impact on speed in urban areas.

**Fuel consumption and CO2**

Park and ride schemes are designed to reduce congestion in urban areas and to shift travel by car to public transport. Some personal transport fuel consumption benefits are to be expected, however there is a lack of data quantifying this effect in the literature. As an
input to the modelling the same fuel saving as for the on-street parking service was assumed, i.e. **0.79% for passenger cars only.**

**Environmental and emissions impacts**

No data was identified for this impact category in the reports reviewed. As an input to the modelling the same impacts as for the on-street parking service were used, as shown below:

- **NO\textsubscript{x}:** 0.26% reduction in urban areas for personal transport
- **PM:** 0.07% reduction in urban areas for personal transport
- **CO:** 0.79% reduction in urban areas for personal transport
- **VOC:** 0.79% reduction in urban areas for personal transport

**Safety**

The eSafetyForum Intelligent Infrastructure Working Group Report suggested that parking information services will have zero impact on safety. Whilst there may be secondary impacts due to reduced congestion in urban areas, no data exists to support this and the safety impacts were therefore assumed to be zero.

**Other impacts**

No data related to other impacts was identified in the reports reviewed.

**Information on alternative fuelled vehicle charging and fuelling stations (iFuel)**

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

**Service overview**

The objective of this service is to broadcast electric vehicle charging point availability and AFV fuelling point information to relevant vehicles.

**Technical information**

- Day 1.5 V2I service
- Bundle 4

This service allows users to be informed of and book charging point time windows for fuelling and charging stations for alternative fuels. This enables a more convenient driving experience and allows for vehicle owners to plan routes according to the location of appropriate refuelling points; eBilling information may also be included. This service is applicable on all road types and is currently focussed on cars, bringing vehicle operation and efficiency benefits. As technologies advance and fleet composition changes, this service may be applicable to additional vehicle types.

**Impact data**

To our knowledge, there are no publically available studies that specifically examine the impacts of this service. This service has a large overlap with the traffic information and smart routing service. This service is therefore considered to be included within the traffic information and smart routing service for the purpose of the modelling.

**Traffic efficiency**

All impacts are included within the traffic information and smart routing service for the modelling.

**Fuel consumption and CO\textsubscript{2}**

All impacts are included within the traffic information and smart routing service for the modelling.
Environmental and emissions impacts

All impacts are included within the traffic information and smart routing service for the modelling.

Safety

All impacts are included within the traffic information and smart routing service for the modelling.

Other impacts

No data related to other impacts was identified in the reports reviewed.

Traffic information and smart routing (SmartR)

The impact data presented in this section are from the 2016 C-ITS deployment study. (Ricardo-AEA, 2016).

Service overview

The provision of traffic information and smart routing services to vehicles is intended to improve traffic efficiency and aid traffic flow management.

Technical information

- Day 1.5 V2I service
- Bundle 5

Traffic flow management is achieved by optimising routes based on traffic flows, traffic lights and speed limits and by offering re-routing suggestions to vehicles based on real-time traffic information status alerts. This service is applicable to all road and vehicle types (except public transport) and is expected to deliver efficiency, vehicle operation and environmental benefits by limiting congestion.

Impact data

The main data sources for the impacts of the traffic information and smart routing service were the eSafetyForum Intelligent Infrastructure Working Group’s Final Report, the iMobility Effects Database (VTT, 2010) and the TNO report on the impact of information and communication technologies on energy efficiency in the road transport sector.

Traffic efficiency

The only report to assess traffic efficiency was the eSafetyForum report. This reported results for three related services: real time event information, real time traffic condition information, and travel time information. All services show a 1-15% reduction in congestion. In the absence of more precise data, the mid-point of this range was used for the modelling, i.e. an 8% improvement in traffic speed for both passenger and freight vehicles – only applicable in urban areas.

Fuel consumption and CO₂

The eSafetyForum report presents results for three services: real time event information, real time traffic condition information, and travel time information, which all show a 1-10% reduction in fuel consumption/CO₂ emissions. Further information about this service is not given and the report does not state whether these are the expected benefits at an EU-level.

In a study performed by TNO on the impact of information and communication technologies on energy efficiency in the road transport sector (TNO, 2009), a service called ‘fuel efficient route choice’ was assessed. This was calculated to have a 2.1% impact on fuel consumption at an EU level. As the emphasis of this service was on maximising fuel efficiency, rather than shortest journey time, the fuel savings benefits are expected to be lower than this value.
Another similar service assessed by TNO is the freight specific, trip departure planning service. The objective of this service is to ensure fleet journey time is minimised, based on real, current and predicted traffic conditions. This is a similar function as the traffic information and smart routing service defined in this report. In the TNO study, the trip departure planning service was estimated to have a 1.8% (reduction) impact on fuel consumption/CO₂ emissions at an EU level, if implemented in all freight vehicles.

Due to limited other data for the traffic information and smart routing service, an average of the figures stated for the two TNO services was used and applied to all vehicles (except public transport) and road types. This gives a 1.95% impact on fuel consumption/CO₂ emissions for passenger and freight vehicles across all road types. This figure is supported by the iMobility Effects Database, which reports a 2% impact on CO₂ emissions at an EU level. (VTT, 2015)

Environmental and emissions impacts

No data was identified for this impact category in the reports reviewed, therefore emissions impacts were scaled using the ratio between fuel/CO₂ impacts and emissions impacts for the in-vehicle speed limit service in urban areas. This resulted in the following impacts on emissions:

- **NOₓ**: 0.4% reduction on motorways, 1.7% reduction on other interurban roads, 0.5% reduction on urban roads
- **PM**: 0.3% reduction on motorways, 0.8% reduction on other interurban roads, 0.1% reduction on urban roads
- **CO**: 0.2% reduction on motorways, 4.2% reduction on other interurban roads, 2.3% reduction on urban roads
- **VOCs**: 0.1% increase on motorways, 6.5% reduction on other interurban roads, 1.7% reduction on urban roads

Safety

No data was identified for this impact category in the reports reviewed. It is likely that this service could indirectly lead to safety benefits due to reduced driver hesitation and reduced congestion, however no reports quantify this effect. In the modelling this service is assumed to have no impact on safety.

Other impacts

No data related to other impacts was identified in the reports reviewed.

**Vulnerable road user protection – pedestrians and cyclists (VRU)**

*The impact data presented in this section are from the 2016 C-ITS deployment study.* (Ricardo-AEA, 2016).

**Service overview**

This is a safety focussed service, which is intended to protect vulnerable road users. In this vase vulnerable road users are considered to be pedestrians and cyclists only.

**Technical information**

- Day 1.5 V2X (where X signifies a pedestrian or cyclist)
- Bundle 7

This service is designed to increase safety by alerting drivers of the presence of vulnerable road users (those outside the vehicle such as pedestrians, cyclists). This may be achieved via communication with a smartphone, or in the case of cyclists, via communication with a C-ITS device fitted on the bike. In the case that installing ITS-G5 capability is not practical within smartphones, this service could be based on a cellular technology, provided it offers
sufficiently low latency. Vulnerable road user protection is applicable to all vehicle types and is expected to bring safety benefits to all road types, however the majority of benefits are expected to be on urban roads.

**Impact data**

To our knowledge, there are currently no publically available studies that specifically examine the impacts of this service, however it is anticipated that results from the VRU ITS project will soon be available.

The eIMPACT project evaluated a non-cooperative intelligent transport service called "pre-crash protection of vulnerable road users". This is similar to the vulnerable road user protection service evaluated in this study, however in eIMPACT it was not considered to be a cooperative system and was assumed to operate by detecting vulnerable road users via sensors. The two services are likely to present information to the driver in a similar manner and safety impacts will occur via similar mechanisms, therefore the data presented can be applied to the cooperative service.

**Traffic efficiency**

No data was identified for this impact category in the reports reviewed. It is assumed that this service will not have an impact on traffic efficiency at an EU level.

**Fuel consumption and CO₂**

No data was identified for this impact category in the reports reviewed. It is assumed that this service will not have an impact on fuel consumption at an EU level.

**Environmental and emissions impacts**

No data was identified for this impact category in the reports reviewed. It is assumed that this service will not have an impact on vehicle emissions at an EU level.

**Safety**

Due to the absence of other data, data from the eIMPACT project for the "pre-crash protection of vulnerable road users" was referenced. This was not considered to be a cooperative system, however the results provide a good indication of the expected impacts of a similar cooperative service, as both services are expected to display similar information to the driver.

Assuming a 100% penetration in EU-25 countries, the eIMPACT study estimated a 1.8% reduction in fatalities and a 1.9% reduction in injuries for the pre-crash protection of vulnerable road users (TNO, VTT, Movea, PTV, BASt, 2008). Discussions with experts confirmed that the majority of benefits of this service will be seen in urban areas. **A 1.8% reduction in fatalities and a 1.9% reduction in injuries has therefore been used for other interurban roads, and urban roads, applied to all vehicle types.** This service was assumed to have no impact on safety on motorways in the modelling.

**Other impacts**

No data related to other impacts was identified in the reports reviewed.
B.2.3.5 Overlap between services

A number of C-ITS services covered in this study have similar functionality, therefore multiple services are likely to overlap and be applicable to the same driving scenarios. For example, on approaching a traffic jam, both the emergency electronic brake light service and traffic jam ahead warning service will be applicable. Therefore in practice, when two or more similar services are deployed, the impacts may not be additional and further benefits from adding additional services may only be a fraction of each additional service if deployed individually.

In order to accurately estimate overall modelling impacts, it is important to capture this interaction between services, to avoid over-optimistic estimation of benefits from bundles of multiple services.

To this end, service overlap was accounted for in the modelling using a service weighting matrix, as shown in Table B-18. This matrix applied a percentage weighting from 0-100% to each service, based on which services would be deployed before it in the progression of scenarios from Policy Option 1 to 3. Weightings were applied in increments of 25%, in an attempt to account for different amounts of overlap between different services. These service overlap values have originally been developed in working groups under the C-ITS platform for the 2016 C-ITS Deployment Study. There were again reviewed by the project team as part of this study, however, no need for changes was identified.

When assessing potential overlap between C-ITS services, it was assumed that the same overlap would apply for all impacts, i.e. if a service eliminates 50% of the safety impacts of another service, it will also eliminate 50% of the fuel consumption impacts.

A full list of overlaps is described below:

- **Traffic jam ahead warning**: it is assumed that 25% of the impacts of traffic jam ahead warning would be eliminated due to the emergency electronic brake light service.

- **Roadworks warning**: it is assumed that 25% of the impacts of roadworks warning would be eliminated due to the emergency electronic brake light service and a further 25% of the impacts would be eliminated due to the traffic jam ahead warning.

- **Weather conditions**: it is assumed that there is significant overlap with hazardous location warning and that 50% of the impacts will be eliminated.

- **Probe vehicle data**: it is assumed that the function of this service is to collect vehicle data to aid road operators and to improve the performance of various other services. Furthermore, it will not be present as a specific service for end-users. All impacts are assumed to be accounted for by other services (100% overlap with other services).

- **Shockwave damping**: it is assumed that 25% of the impacts of shockwave damping would be eliminated due to the emergency electronic brake light service.

- **Off street parking information and management**: it is assumed that there is 100% overlap with other parking services (on street parking information and management and park & ride information), so no distinction is made when modelling the impact of these services.

- **Park & Ride information**: it is assumed that there is 100% overlap with other parking services (on street parking information and management and off-street parking information and management), so no distinction is made when modelling the impact of these services.
Table B-18: Service overlap matrix

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<th>EBL</th>
<th>EVA</th>
<th>SSV</th>
<th>TJW</th>
<th>HLN</th>
<th>RWW</th>
<th>WTC</th>
<th>VSPD</th>
<th>VSGN</th>
<th>PVD</th>
<th>SWD</th>
<th>GLOSA</th>
<th>SigV</th>
<th>TSP</th>
<th>iFuel</th>
<th>Pinfo</th>
<th>PMang</th>
<th>P&amp;Ride</th>
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<th>VRU</th>
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<tr>
<td>Light injuries</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>75%</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>75%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Material damages</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>75%</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>75%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Average speed</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>75%</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>75%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Percentages equal the fraction of impacts included in the modelling. Red text signifies overlaps with another service.

EBL = emergency brake light, EVA = emergency vehicle approaching warning, SSV = slow or stationary vehicle warning, TJW = traffic jam ahead warning, HLN = hazardous location notification, RWW = roadworks warning, WTC = weather conditions warning, VSPD = in-vehicle speed limits, VSGN = in-vehicle signage, PVD = probe vehicle data, SWD = shockwave damping, GLOSA = green light optimal speed advisory/time to green, SigV = signal violation /intersection safety, TSP = traffic signal priority request by designated vehicles, iFuel = information on alternative fuelled vehicle charging and recharging stations, Pinfo = on-street parking information and management, PMang = off-street parking information and management, P&Ride = Park & Ride information, SmartR = Traffic information and smart routing, VRU = vulnerable road user protection.
B.2.4 C-ITS technology and service costs

This section describes the C-ITS supporting technology and service costs used in the CBA. Cost data makes up the final main input element for the CBA, allowing the uptake and penetration rates for different services to be translated into costs, in order to compare them directly to the estimated benefits from the various EU-level impacts calculated from the modelling.

B.2.4.1 Introduction to C-ITS sub-systems

In order to fully understand the costs associated with the deployment of C-ITS services, it is necessary to consider the cost of the hardware/devices and associated software and services used to facilitate those C-ITS services. These devices can be broadly categorised into four types:

1. Central ITS sub-systems, which may be part of a centralised traffic management system. One such sub-system is able to manage C-ITS services for an entire city, or road operator, or national highway system etc. Deployment of other ITS sub-systems, such as C-ITS infrastructure/roadside units will require a central system for management purposes.

2. Personal ITS sub-systems such as smartphones can enable V2I communications along suitably equipped roads/regions, or in the future, may be able to support V2V communications if equipped to use the correct communications protocols. Note that in this study, it is assumed that personal ITS sub-systems are not able to offer Day 1 safety related V2V services (Bundle 1) because the low-latency requirements of these services are not likely to be met through 3G/4G connectivity.

3. Vehicle ITS sub-system, which are either fitted by the vehicle manufacturer or retrofitted to the vehicle, and are attached to the vehicle communication buses – these can enable both V2V communications and V2I along suitably equipped roads/regions. Note that retrofitted vehicle ITS sub-systems are outside the scope of this study, as the feasibility/functionality of retrofitting is not yet determined.

4. Roadside ITS sub-systems such as beacons on gantries, poles, smart traffic lights, etc. which allow V2I communications along specific stretches of roads.

B.2.4.2 Cost data overview

Cost items collected

For each of the C-ITS sub-systems listed in Section B.2.4.1, data related to the following parameters was collected:

1. Upfront costs, i.e. one-off costs incurred at the point of installation/commissioning.
2. Ongoing costs, i.e. the recurring costs associated with operating each sub-system.
3. Equipment lifetime, to establish whether it was necessary to account for replacement costs within the lifetime of the CBA modelling (2015 to 2035).
4. The cost owner, to enable an estimation of the impact of different cost items on the various key stakeholders in the deployment of C-ITS services.

Where applicable, the costs presented below in the summary tables have been converted to Euros, expressed in 2015 prices. As most of the costs obtained were costs to OEMs, they have been marked up to convert to end-user costs. A mark-up value of 1.51 has been applied, developed by the project team and verified with stakeholders. Inflation is based on the harmonised index of consumer prices (HICP) of the EU-28 (EC Eurostat, 2016).

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ERTICO, "Communication Technologies for future C-ITS service scenarios" (2015)
Technology learning rates

The majority of the systems deployed to support the rollout of C-ITS services are currently at a relatively early stage of maturity and costs are likely to improve through time. To account for this, a learning rate of 15% is applied to all up-front costs for in-vehicle and roadside ITS sub-systems. That is, for every doubling in installed volume, up-front costs reduce by 15%. These learning rates are based on an analysis of low CO₂ technologies performed by the US EPA and NHTSA, which states that different learning rates apply depending on the level of maturity of the technology (US EPA, NHTSA, 2012). The originally developed rate of 10% was adjusted up by 5% to reflect feedback from experts at the February 2018 stakeholder workshop.

To avoid a strong decrease in costs due to the step increase in units in early years, starting volumes have been defined for vehicles and RSUs. Only when these starting volumes are reached, learning rates begin to apply. For vehicles the starting volume is set to 30 million units. For RSUs the starting volume is set to 50,000 units. Before the starting volumes are reached, a uniform 2% annual reduction is assumed, in line with (Analysys Mason, 2017).

B.2.4.3 Sources of information

Literature

A review of the literature that was released or made available since the last study was carried out, but only limited data was obtained and the main input was expert consultation. As a result, cost data was included in the data requests that were sent out to deployment project representatives and ITS experts (see Annex A). Box B-6 below displays the main literature sources of cost data that were used in the 2016 study.

Box B-6: Overview of the main sources of literature used in the 2016 C-ITS Deployment study (Ricardo-AEA, 2016)

The cost data collection exercise built on our extensive literature review of over 100 documents from Task 1, which covered various aspects of C-ITS services and related technologies. Within this long list, a number of key sources for the cost data collection task were identified, as listed below:

- COMeSafety, BMW: D2.3 Cost Benefits Analysis & Business Model Elements for Deployment (Ségarra et al., 2014)
- CVIS costs, benefits and business models (Berger et al., 2010)
- NHTSA, US DoT: Vehicle-to-Vehicle Communications: Readiness of V2V Technology for Application (Powell et al., 2014)
- COBRA, TNO: Deliverable 2 Methodology framework, Update (Faber et al., 2013)
- CODIA - Final study report (Kulmala et al., 2008)
- SAFESpot SP6 – BLADE – Business models, Legal Aspects, and Deployment (Luedeke et al., 2010)
- EasyWay Business case and benefit-cost assessment of EasyWay priority cooperative services (Kulmala et al., 2012)
Expert input

Data requests were distributed to deployment project representative and ITS experts. A number of responses were received from experts regarding cost data including, VW, BMW, NordicWay, InterCor NL and Autotalks. Furthermore, cost data from two ITS technology suppliers were provided by the Dutch Ministry of Infrastructure and Water Management. Due to the strict confidentiality of some of the data, in the following only the changes based on the newly provided data is presented and not the data as received.

Participants at the workshop were also presented with the costs and given the opportunity to provide feedback during the workshop and in the survey.

As a result of the review process and the feedback received a number of cost data inputs were updated, including:

- Data costs for personal ITS sub-systems
- Smartphone application development cost
- Public Key Infrastructure (PKI) costs across ITS sub-systems
- RSU costs

Base year

Given the varying base years for cost data originating from different data sources, all pre-2015 costs have been inflated to 2015 levels using the Eurostat Harmonised indices of consumer prices (HICP) (European Commission, 2015).

B.2.4.4 Central ITS sub-systems

Central ITS sub-systems are likely to be integrated into existing traffic management centres (TMCs). One such sub-system is likely to have the ability to manage an entire city, road operator, national highway system etc. A central ITS sub-system is necessary so that roadside sub-systems are connected to a central system, where data can be analysed and used to enable effective traffic management and the deployment of V2I services.

In this cost-benefit analysis central ITS sub-system costs are considered on a Member State level; costs have been calculated per Member State, depending on the level of infrastructure penetration.

Business model

It is assumed that central ITS sub-systems will be integrated into existing traffic management centres and that additional TMCs will not need to be built to support the management of C-ITS services. Consequently, the costs described in this section only refer to the cost of additional equipment/services required to connect the roadside units to TMCs, back office integration costs, etc. It is assumed that these costs are borne by the highways agencies/urban transport authorities in each Member State.

In addition to the TMC integration costs, it is assumed that software applications are required to deliver the C-ITS services to various personal or in-vehicle ITS sub-systems. These must additionally be developed in each Member State and it is assumed that these costs are borne by the transport/highways agencies in each Member State.

Summary of inputs to the cost-benefit analysis

A summary of the key cost assumptions used in the CBA is given in Section B.2.4. These are discussed in more detail below.
Table B-19. Breakdown of costs for central ITS sub-systems (front runner country)

<table>
<thead>
<tr>
<th>Cost item</th>
<th>Input</th>
<th>Year</th>
<th>Cost owner</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upfront costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration of roadside units into TMC. Interface to urban standards/protocols</td>
<td>€1,500,000</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Integration of roadside units into TMC. Interface to inter-urban standards/protocols</td>
<td>€1,500,000</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Interface from roadside unit to local traffic controller (urban)</td>
<td>€1,000,000</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Interface from roadside unit to local traffic controller (inter-urban)</td>
<td>€1,000,000</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td><strong>Ongoing costs (per year)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back office operations and maintenance (urban)</td>
<td>€250,000</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Back office operations and maintenance (inter-urban)</td>
<td>€250,000</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Application development costs (urban)</td>
<td>€301,800</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Application development costs (inter-urban)</td>
<td>€301,800</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
</tbody>
</table>

**Upfront costs**

It is assumed that each roadside unit will be connected to a TMC. Based on conversations with industry experts, it is assumed that each EU Member State operates with different road traffic standards/protocols. Two major upfront cost items are relevant to deploying central ITS sub-systems in each Member State:

- A **cost for developing a TMC interface** for each Member State. Based on discussions with industry experts, development of a TMC interface is likely to cost between €1mn- €2mn. An average cost per interface of **€1.5mn** has been used in this CBA. Previous studies (EasyWay and COBRA) have suggested a cost of €500,000 per roadside ITS station to cover integration costs with TMCs. Based on this figure an average cost of €850,000 per TMC per country was calculated. This compares well with the €1.5mn cost estimation used in this study, considering that previous studies have assumed an ITS sub-system range of €300,000-500,000.

- An **interface to local traffic controllers** (e.g. traffic lights) for roadside ITS sub-systems. Based on discussions with industry experts, a cost of **€1mn** per interface has been assumed.

Furthermore, each Member State is likely to have different urban traffic standards and inter-urban traffic standards. The total cost for integration of C-ITS services is therefore estimated at **€2.5mn** each for urban and inter-urban areas respectively within each Member State.

These costs are triggered only once roadside ITS sub-system penetration reaches 10% across urban areas and 5% across inter-urban areas.

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24 Assuming a roadside ITS sub-system range of 1km and the number of roadside units deployed in the baseline scenario
Ongoing costs

Two principal ongoing costs are assumed to be incurred, as follows:

- The cost for **maintaining the TMC back-office and local controller interfaces**, estimated at 10% of capital costs based on the COBRA study (TNO, 2013), or **€250,000** per year for urban and inter-urban areas respectively.

- A cost for **developing and maintaining software applications** to deploy services to personal and in-vehicle ITS subs-systems, estimated at **€300,000** per year (€301,800 with inflation to 2015 value). The development, maintenance and improvement of C-ITS mobile applications has been estimated to require between 1-5 FTEs (full time equivalents) and will be paid for by highways agencies via an annual service fee to app developers. Three FTEs are estimated to cost €300,000 per year, based on the COMeSafety2 cost-benefit analysis (BMW, 2014). As for the other central ITS sub-system costs, separate applications will be required for urban traffic standards and inter-urban traffic standards in each Member State, so this cost is assumed to apply to both urban and inter-urban areas.

The total ongoing cost per Member State and central system is therefore **€551,800** per year, with this cost being triggered for urban areas when total ITS sub-system penetration reaches 10%, and for inter-urban areas penetration reaches 5%.

**Lifetime**

The lifetime of the TMC integration is assumed to exceed the lifetime of the modelling (which runs to 2035) and therefore is not considered relevant for this section.
B.2.4.5 Personal ITS sub-systems

Personal ITS sub-systems such as smartphones can enable V2I communications along suitably equipped roads. In the future, smartphones may also enable V2V communications if equipped to use the correct communications protocols.

The objective of this cost-benefit analysis is to assess the costs and benefits of three realistic C-ITS Policy Options during the years 2015-2035 and to compare these to the baseline. To ensure a robust methodology, information for the modelling was drawn from current market trends, data on comparable existing technologies and knowledge of potential business models. Based on our analysis for the baseline scenario and discussions with key stakeholders, it is assumed that C-ITS services on personal ITS sub-systems will only be provided through smartphones.\(^\text{25}\)

In the future it is possible that other types of handheld devices will have the potential to support C-ITS services, however during the timeframe considered for this cost-benefit analysis these are likely to account for only a small percentage of personal ITS sub-systems. Furthermore, no cost or performance data exists for these unknown future devices on which to base modelling inputs and they are therefore not modelled in this study.

In the time period considered for the modelling it is assumed that personal ITS sub-systems are not able to support the safety V2V services in Bundle 1, as these devices will not be connected to vehicle information systems.

It is assumed that personal ITS sub-systems are only available in the aftermarket, to any vehicles that are not already equipped with in-vehicle C-ITS sub-systems. Costs are assumed to be consistent across all vehicle categories.

**Business model**

As with any emerging technology, C-ITS services could be offered via a number of different business models. The method selected is likely to depend on the interaction between key stakeholders in the field and may ultimately vary by Member State, Highways Agency and technology/software provider.

Three options that have been suggested for smartphones are as follows:

- **Subscription based model**: In a subscription based business model, end-users would not be charged to download the application but would pay an annual subscription fee for use of the service. The subscription fee would be used to cover software development costs and enable the end-user to receive updates to the application during the subscription period. Any cellular data usage associated with using the application would be covered by the end-user.

- **App store/online marketplace based model**: On the other hand, in an app store based business model, there would be a one-off fee to download the application, with no additional subscription fees. In this case, the one-off fee would be set at a level sufficient to cover the software development and update costs. Any cellular data usage associated with using the application would be covered by the end-user.

- **Free model**: Alternatively, C-ITS services may be provided for free to smartphone users, for example by national highways agencies. In this business model, an application is developed and maintained by an app developer who bears the cost, although they may be supported by a public body or OEM. In this business model, cellular data usage will be covered by the end-user, however there will be no upfront fee to download the app and no subscription fees to

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\(^{25}\) This is a simplification compared to the previous study, that distinguished between implementation through smartphones and in-car navigation devices. This simplification makes the overall cost assumptions more transparent and focused on functionality, while having limited impact on overall cost results.
access the service. The funding body of the applications may choose to recoup some of its costs through e.g. allowing advertising within the app.

Based on discussions with WG1 members and current European pilot projects (such as NordicWay), the most likely business model to be offered for C-ITS services is deemed to be the ‘free’ model described above. Therefore, it has been decided to model only the ‘free’ business model in the cost-benefit analysis. As a result, deploying additional C-ITS service bundles which rely on the same underlying communications technology, does not incur any additional costs in the CBA modelling.

Summary of inputs to the cost-benefit analysis

A summary of the key assumptions and inputs to the cost-benefit analysis for smartphones are shown in Box B-7 below. A full breakdown of costs is given in Table B-20. The following sections discuss these aspects in more detail.

Box B-7. Summary of key assumptions and inputs to the cost-benefit analysis for smartphones

<table>
<thead>
<tr>
<th>Key assumptions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Personal ITS sub-systems are only available via the aftermarket to existing vehicles that are not already equipped with in-vehicle ITS sub-systems</td>
</tr>
<tr>
<td>• Costs are assumed to be consistent across all vehicle categories</td>
</tr>
<tr>
<td>• Smartphones will only provide V2I services, via the cellular network</td>
</tr>
<tr>
<td>• Smartphones are already owned by the user – i.e. no up-front purchase costs are incurred</td>
</tr>
<tr>
<td>• C-ITS services will be available to the end-user via a free model.</td>
</tr>
</tbody>
</table>

Table B-20. Breakdown of costs for Smartphones

<table>
<thead>
<tr>
<th>Cost item</th>
<th>Input</th>
<th>Year</th>
<th>Cost owner</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upfront costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>€0</td>
<td>2015</td>
<td>End-user</td>
</tr>
<tr>
<td>Smartphone development</td>
<td>€500,000</td>
<td>2015</td>
<td>App developer</td>
</tr>
<tr>
<td><strong>Ongoing costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(per year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>€3.94</td>
<td>2015</td>
<td>End-user</td>
</tr>
<tr>
<td>Software updates</td>
<td>€100,000</td>
<td>2015</td>
<td>App developer</td>
</tr>
</tbody>
</table>

**Upfront costs**

In the cost-benefit analysis for this project, the upfront cost of the development of the application is not borne by the end-user. It is assumed that smartphones are already owned by the user and that C-ITS services will be developed and provided for free by highways agencies, as described above. This approach is currently being followed by the NordicWay pilot project, which is aiming to deploy cellular based C-ITS services. To cover the cost of maintenance, an ongoing cost has been included for urban and inter-urban standards in each Member State.

It is assumed that C-ITS apps will follow the business model of the most widely used navigation apps, with a few competing app providers across Europe. In the start year
(2019) two apps are assumed to be available, with every additional 5% in uptake another app will be required until a total number of 7 apps is reached.

Up-front app development costs are assumed to be €500,000 per app. This reflects the upper end of app development costs reflecting the technical complexity, communications compatibility and scale that would be required. This value is in line with estimated app development costs given by COMeSafety 2 and Score@F project as well as general online website resources.

**Ongoing costs**

As discussed above, no annual subscription fees are included for use of the C-ITS smartphone application, as all services are assumed to be provided for free by national Highways Agencies/urban transport authorities.

Use of C-ITS applications in smartphones will require the user to transmit and receive additional data via the cellular network. To cover this additional data usage, a cost of **€3.94 per user per year** has been estimated. This is based on estimates of data volumes required to offer C-ITS services cited in a US DoT NHTSA report on C-ITS applications (NHTSA, 2014). A price of €4.50/GB is assumed, which is the 2019 wholesale cost of 1GB roaming data in the EU (European Commission, 2017). The value from the year 2019 was chosen because deployment of C-ITS through personal devices is modelled to begin in this year.

Ongoing costs for app developers are linked to necessary software updates, which are assumed to be 20% of the upfront costs, thus €100,000 per year. Online research suggests that the value of 20% is a recognised industry norm (Diehl, D., 2016).

**Lifetime**

Given the assumptions that C-ITS applications are offered free to the user and that smartphones are already owned by the end-user for other purposes, equipment costs and lifetimes are not relevant to smartphones for the cost-benefit analysis.

**B.2.4.6 In-vehicle ITS sub-systems**

In-vehicle ITS sub-systems can be either fitted by the vehicle manufacturer or retrofitted to the vehicle, and are attached to the vehicle communication buses. These can enable both V2V communications and V2I along suitably equipped roads. Retrofitted vehicle ITS sub-systems are outside the scope of this study, so this chapter only details costs for systems installed in new vehicles.

In the cost-benefit analysis for this project it is assumed that all vehicles are capable of delivering both short-range based services and cellular based services, in line with a technology neutral approach to service delivery.

Wherever possible cost data was defined separately for the three vehicle types modelled in the CBA, i.e. personal transport, freight vehicles and buses. Where disaggregated data was not available, costs were assumed to be constant across different vehicle types.

**Business model**

A simple business model is adopted in the cost-benefit analysis, whereby costs are only included for the additional equipment/software required to deliver C-ITS services in new vehicles. Additional up-front equipment, integration, installation and software development costs are included at cost price (i.e. OEM costs), whilst a number of additional ongoing costs are incurred by both the OEM and end-user.

No additional subscription or up-front costs are included to access the C-ITS services other than the technology/software that enables them. This is consistent with our assumptions around central and personal ITS sub-systems, whereby it is assumed that C-ITS applications and services are offered free to the end-user, provided they have the equipment required to deliver them.
Clearly a number of the costs assumed to be incurred by the OEMs will eventually be passed on to the consumer through applying a mark-up (for example the NHTSA study assumes a 51% mark-up between OEM cost and consumer price on all vehicle components) (NHTSA, 2014).

**Summary of inputs to the cost-benefit analysis**

A summary of the key assumptions and inputs to the cost-benefit analysis is shown in Box B-8 below. A full breakdown of costs is given in Table B-21. The following sections discuss these aspects in more detail.

**Box B-8. Summary of key assumptions and inputs to the cost-benefit analysis for vehicles with short-range (cost assumptions based on ITS-G5 implementation) and cellular**

**Key assumptions:**

- In-vehicle ITS sub-systems are only available to new vehicles coming off the production line
- Where disaggregated data is not available, costs are assumed to be consistent across all vehicle categories
- Only costs associated with the equipment/software required to deliver C-ITS services to vehicles are included, as well as associated integration, testing, software development and ongoing costs
- Costs are assumed to be incurred by the vehicle OEM, except for ongoing maintenance and secure communications costs
- Two DSRC antennae and transmitter/receivers are assumed necessary, one to send and receive basic safety messages, the other for the security aspects of V2V communication

**Table B-21. Breakdown of costs for vehicles with ITS-G5 and cellular**

<table>
<thead>
<tr>
<th>Cost item</th>
<th>Input</th>
<th>Year</th>
<th>Cost owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upfront costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSRC transmitter/receiver (for 2)</td>
<td>€160.04</td>
<td>2015</td>
<td>End-user</td>
</tr>
<tr>
<td>DSRC antenna (for 2)</td>
<td>€12.31</td>
<td>2015</td>
<td>End-user</td>
</tr>
<tr>
<td>Electronic Control Unit</td>
<td>€55.40</td>
<td>2015</td>
<td>End-user</td>
</tr>
<tr>
<td>Wiring</td>
<td>€11.08</td>
<td>2015</td>
<td>End-user</td>
</tr>
<tr>
<td>Cellular equipment on-board</td>
<td>€12.31</td>
<td>2015</td>
<td>End-user</td>
</tr>
<tr>
<td>Installation</td>
<td>€8.47</td>
<td>2015</td>
<td>End-user</td>
</tr>
<tr>
<td>Development &amp; integration</td>
<td>€28.48</td>
<td>2015</td>
<td>End-user</td>
</tr>
<tr>
<td>Vehicle software development</td>
<td>€2.85</td>
<td>2015</td>
<td>End-user</td>
</tr>
</tbody>
</table>

Development & integration, vehicle software development and vehicle software (updates) costs were calculated separately for freight vehicles and buses. All other costs are assumed to be the same, irrespective of vehicle type.
### Ongoing costs (per year)

<table>
<thead>
<tr>
<th>Cost item</th>
<th>Input</th>
<th>Year</th>
<th>Cost owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>5%</td>
<td></td>
<td>End-user</td>
</tr>
<tr>
<td>Secure communications</td>
<td>€2.56</td>
<td>2012</td>
<td>End-user</td>
</tr>
<tr>
<td>Vehicle software (updates)</td>
<td>€3.02</td>
<td>2015</td>
<td>OEMs</td>
</tr>
<tr>
<td>Cellular data</td>
<td>€3.94</td>
<td>2019</td>
<td>End-user</td>
</tr>
</tbody>
</table>

### Upfront costs

For the cost–benefit analysis, a total upfront cost per vehicle (to the OEM) of **€290.94** was calculated. This is made up of in-vehicle equipment costs (€251.14), installation (labour) costs (€8.47), C-ITS integration/development/testing costs (€28.48), and software development costs (€2.85).

### Equipment and installation costs

To enable C-ITS services based on a hybrid communication approach, a number of in-vehicle components are required, including: two DSRC transmitter/receivers, two DSRC antennas, an electronic control unit, cellular on-board equipment and additional wiring. In contrast to the NHTSA study, a cost for an in-vehicle screen has not been included; instead, it is assumed that all vehicles equipped with C-ITS services already have some form of display where C-ITS notifications could be presented. Although GPS is required to deliver C-ITS services, GPS costs (estimated to be c. $9 in 2012) are also not included in this analysis as it is assumed that the majority of new vehicles will already have GPS installed by the time C-ITS services are deployed. NHTSA estimated that over 50% of new passenger cars had GPS installed in 2011, with this percentage expected to rise as navigation systems are installed in more vehicles (NHTSA, 2014).

Two DSRC antennas and transmitter/receivers are assumed to be necessary – one will be used to send and receive basic safety messages, whereas the other will be required for the security aspects of V2V communication, such as receiving certificates and certificate revocation lists (NHTSA, 2014). The equipment costs used in this study are derived from the U.S. DoT NHTSA Vehicle-to-Vehicle Communications: Readiness of V2V Technology for Application report (NHTSA, 2014), where they are presented as a Day 1 cost per component to the OEM in 2012 dollars. These figures were converted to 2012 Euros to give the values listed in Table B-21.

Installing the additional equipment in vehicles also has implications in terms of labour costs. The cost to install the components listed above is estimated to be $6.88, in 2012 US dollars (NHTSA, 2014). This is equal to £5.35 (2012 Euros)\(^{27}\).

The costs in the NHTSA study for ITS-G5 equipment are broadly comparable with EU studies such as CODIA (£150 in 2020, €120 in 2030) and COBRA (€100 - €250, depending on complexity of system and level of driver assistance). The COMeSafety2 (€30-€50 depending on volume, for an ITS-G5 unit integrated in existing telematics control units) and EasyWay studies (€50 in a 100% penetration scenario) suggest slightly lower costs, however it is not clear whether these include two DSRC antennas and two DSRC transmitter/receivers as suggested by the NHTSA study.

### Integration of C-ITS technology, development and testing costs

\(^{27}\) USD/EUR Exchange rate of 0.7781 (January 2012 – December 2012 period average) Source: www.oanda.com/currency/historical-rates/
The cost of integrating new C-ITS services into passenger cars is estimated to cost €18.86 per vehicle. This covers activities such as linking the equipment required to receive and process the signals for C-ITS services to the rest of the vehicle’s safety and other systems, and carrying out all safety and functionality testing required for certification. It is assumed that:

- Based on discussions within WG1, the total cost of integrating the equipment required to deliver C-ITS services would be approximately €5mn per vehicle model.
- Integration and testing would need to be carried out separately for each of a manufacturer’s vehicle models, with no savings from deploying the service across multiple models.
- On average, each manufacturer sells 12 models of passenger car in Europe\(^\text{28}\), based on an analysis of the top 7 manufacturers operating in Europe (ranked by annual sales).
- Each model has a 4 year facelift cycle, which is consistent with the uptake rates used for new vehicles in the cost-benefit analysis.
- The average number of vehicles sold per model by each manufacturer over the 4 year facelift cycle is c. 280,000\(^\text{29}\).
- The resultant cost per vehicle sold is €5,000,000/280,000 = c. €18 up-front costs.

The cost of integrating new C-ITS services into freight vehicles is estimated to cost €63.49 per vehicle. This was calculated using the same methodology as for passenger cars\(^\text{30}\) but was based on an analysis of the top three LCV (light commercial vehicles, <3.5t), top three CV (commercial vehicles, >3.5t) and top three HCV (heavy commercial vehicles, >16t) manufacturers operating in Europe (ranked by annual sales) (ACEA, 2011 - 2013). The cost of integrating new C-ITS services into buses is assumed to cost the same as for freight vehicles.

**Software development and integration costs**

Software development costs have been estimated to be €1.89 per vehicle, based on a 4 year facelift cycle. This covers the cost of developing the software to support a range of C-ITS services, i.e. the software to process the incoming/outbound signals and to decide what to do with them, before sending further signals to the vehicle’s CAM bus to request responses from various vehicle systems (e.g. displays, avoidance manoeuvres, etc.).

The assumptions used here are as follows:

- The initial software development costs would be approximately €1mn per model, based on a team of ten engineers working for a year to develop the software (BMW, 2014).
- Software could be shared to some extent across different vehicle models, due to there being significant overlap between the software deployed to different vehicle models from the same OEM. However, the differing complexity of different categories of vehicles (e.g. A-category versus E-category) would mean that individual vehicle models would still incur approximately 50% of the total development costs described above.

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\(^{28}\) Based on an analysis of passenger car product ranges of the 7 manufacturers with the largest market share in Europe, in 2015 (SOURCE: ACEA).

\(^{29}\) Based on an analysis of passenger car product ranges of the 7 manufacturers with the largest market share in Europe, in 2015 (SOURCE: ACEA).

\(^{30}\) A 5 year model facelift cycle was assumed for CVs (>3.5t) and HCVs (>16t). For LCVs (<3.5t) a 4 year model facelift cycle was assumed.
This cost can be approximated as detailed below, however for the cost benefit analysis, this was calculated on a per manufacturer basis for the 7 manufacturers with the largest market share in Europe, to give an average cost of €1.89.

- The average number of vehicles sold per model by each manufacturer over the 4 year facelift cycle is c. 280,000.
- The resultant cost per vehicle sold is €1,000,000 x 50% / 280,000 = c. €1.8 upfront costs
- This software would need to be maintained by a team of 3-5 individuals full-time – as discussed in the ongoing costs section.

Software development costs have been estimated to be €6.35 per vehicle for freight vehicles. This was calculated using the same methodology as for passenger cars but was based on an analysis of the top three LCV, top three CV and top three HCV manufacturers operating in Europe (ranked by annual sales) (ACEA, 2011 - 2013). The software development costs for buses are assumed to cost the same as for freight vehicles.

**Ongoing costs**

Ongoing costs are composed of maintenance, secure communications, data costs and OEM maintenance of in-vehicle software:

- The additional equipment installed to support C-ITS services in new vehicles is likely to lead to incremental maintenance costs above those that would normally be incurred. A maintenance cost equal to 5% of the capital cost of C-ITS equipment per year is assumed in this study. It is assumed that this cost is borne by the vehicle end-user.
- A secure communications management system is necessary for vehicles to provide and receive secure and trusted communications. The cost of secure communications was estimated in the NHTSA report to be $3.14 (2012 dollars) per vehicle, which is equivalent to €2.56 (2012 Euros). It is assumed that this cost is borne by the vehicle end-user.
- The data cost is based on estimates of data volumes required to offer C-ITS services (and a price of €4.50/GB) cited in a US DoT NHTSA report on C-ITS applications (NHTSA, 2014). The data cost for vehicles is assumed to be the same as for smartphones (€3.94 per year).
- The cost of maintaining in-vehicle software after release, to provide updates where necessary throughout a model’s typical lifecycle was estimated to be €3.02 per passenger car per year. This cost can be approximated as detailed below, however for the cost benefit analysis, this was calculated on a per manufacturer basis for the 7 manufacturers with the largest market share in Europe:
  - This has been estimated to require 3-5 full time staff members (at €100k per year) for each vehicle model,
  - 50% of these costs are shared between models, as per the up-front vehicle software development costs.
  - The average number of vehicles sold per model by each manufacturer is c. 70,000 per year.

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31 A 5-year model refresh cycle was assumed for freight was assumed.
32 USD/EUR Exchange rate of 0.7781 (January 2012 – December 2012 period average) Source: www.oanda.com/currency/historical-rates/
This translates to an annual cost of €400,000 x 50% / 70,000 = c. €2.85 per vehicle. It is assumed that this cost is borne by OEMs, alongside the up-front integration and software development costs.

The cost of maintaining in-vehicle software in freight vehicles and buses was estimated to be €12.70 per freight vehicle per year. This cost was calculated using the same methodology as for passenger cars but was based on an analysis of the top three LCV, top three CV and top three HCV manufacturers operating in Europe (ranked by annual sales) (ACEA, 2011 - 2013). The cost of maintaining in-vehicle software in buses was assumed to cost the same as for freight vehicles.

A number of studies point to the potential effect of C-ITS services on insurance costs (particularly for safety-focused C-ITS services), however due to the lack of data available to support this assertion, these benefits were not included in the analysis.

**Lifetime**

The lifetime of all new vehicles has been estimated to be 12 years, based on the EasyWay and COBRA studies (EasyWay Cooperative Systems Task Force, 2012; TNO, 2013). Given that the lifetime of the modelling is limited to 2030, with initial deployments starting 2018, it is not necessary to consider replacements within this study.

**B.2.4.7 Roadside ITS sub-systems**

**Roadside ITS sub-systems** such as beacons on gantries, poles etc., allow V2I communications along specific stretches of roads. For the purposes of the cost-benefit analysis, roadside ITS sub-systems for ITS-G5 communication are divided into the following two categories:

- **Upgrades to existing roadside infrastructure/roadside units** to enable the delivery of C-ITS systems via ITS-G5. These are relevant in urban areas only, where it is assumed that roadside ITS sub-systems are provided through upgrading existing traffic light systems.

- **Installation of new roadside units** to provide additional ITS-G5 coverage. These are relevant to inter-urban areas, where it is assumed that the required infrastructure is not already in place and that roadside ITS sub-systems must be installed from scratch.

It is recognised that there is a large variation in costs reported for RSUs, which varies by country, manufacturer, functionality and road type. Discussion with stakeholders suggest that installations costs of RSUs may be higher on highways than for urban areas.

**Upgrades to existing roadside ITS sub-systems**

**Business model**

It is assumed that the cost of deploying, running and maintaining upgraded roadside ITS sub-systems is assigned to relevant urban transport authorities. Upgrades occur to existing signalised traffic junctions at a rate determined by the various deployment scenarios. It is assumed that one upgraded system is required per urban signalised junction and that this unit is compatible with all of the urban-related services offered in the scenarios, with no additional costs incurred for deploying additional services.

All costs associated with integrating roadside ITS sub-systems into central traffic management centres (TMCs) and with local traffic controllers, are dealt with separately in the central ITS sub-system category. The costs associated with providing software and applications allowing end-users to access the V2I services that roadside ITS sub-systems facilitate are discussed in the central, personal and in-vehicle ITS sub-system categories.

**Summary of inputs to the cost-benefit analysis**
A summary of the key assumptions and inputs to the cost-benefit analysis for existing roadside infrastructure is shown in Box B-9 below. A full breakdown of costs is given in Table B-22. The following sections discuss these aspects in more detail.

Box B-9. Summary of key assumptions and inputs to the cost-benefit analysis for upgrades to existing roadside infrastructure

Key assumptions:

- Upgraded roadside ITS sub-systems only relevant to urban areas, with a growing percentage of all signalised junctions equipped in the scenarios – this is the case across all sensitivities
- One upgraded system is required per upgraded urban signalised junction
- Upgraded roadside ITS sub-systems have an additional power consumption of 15 – 20 W
- Central ITS sub-system integration costs and software application development costs accounted for separately in Section B.2.4.4.
- Upgraded roadside ITS sub-system lifetime: 10 years

Table B-22. Breakdown of costs for upgraded roadside units

<table>
<thead>
<tr>
<th>Cost item</th>
<th>Input</th>
<th>Year</th>
<th>Cost owner</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upfront costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment/hardware</td>
<td>€3,000.00</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Installation/mounting</td>
<td>€1,500.00</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td><strong>Ongoing costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular maintenance</td>
<td>5%</td>
<td>2014</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Power consumption</td>
<td>€18.40</td>
<td>2014</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Data</td>
<td>€200.56</td>
<td>2013</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Secure communications</td>
<td>€37.91</td>
<td>2013</td>
<td>Highways Agency</td>
</tr>
</tbody>
</table>

**Upfront costs**

The total upfront cost for upgrading an existing roadside unit to be capable of delivering C-ITS functionality has been estimated to be €4,500 based on a literature review and discussions with industry experts during a teleconference held with relevant WG1 members on 12th October 2015. This is composed of:

- An equipment/hardware cost, estimated to be €2,500 to €3,500 for a device such as a plug-in unit, situated on top of an existing pole/pantry and capable of 802.11p wireless communication. This unit includes a box (~2kg), omnidirectional antenna, processor and security chip. An equipment cost of €3,000 has been assumed, which is in the middle of the suggested cost range.
- Installation and mounting costs will vary depending on the complexity of installation. A simple installation may cost €500, whereas a more complex installation would be in the region of €2,500. An average value of €1,500 has been assumed.

**Ongoing costs**

The annual ongoing cost per roadside unit is broken down as follows:
• Regular maintenance is assumed to be 5% of the capital cost per year. Several studies have cited this percentage for maintenance, such as the COBRA study and US focussed NHTSA US DoT Connected Vehicle Field Infrastructure Footprint Analysis (TNO, 2013; NHTSA, 2014). Regular maintenance will include activities such as realigning the antennas, rebooting hardware, checking system operational status and other routine checks (NHTSA, 2014).

• Power consumption: WG1 members advised that power consumption required for C-ITS functionality would be in the range of 15 – 20 W for an upgraded roadside unit. Using the second half of 2014 EU industrial average electricity price of €0.12 per kWh leads to a cost of €18.40 per year per roadside unit (Eurostat, 2015).

• Data costs, which were based on the COBRA study and were calculated to be €200 per year, per upgraded roadside unit (TNO, 2013).

• Secure communications: An extensive study was carried out by the US DoT to assess the costs of secure communications. It assumes that a security credentials management system will need to be developed and implemented (most likely by a private company) and suggests an annual cost of $50 per roadside unit to keep security credentials up to date (NHTSA, 2014). This is equivalent to €37.91 per year.

Lifetime

A lifetime of 10 years has been assumed for roadside ITS sub-systems. This is in keeping with the EasyWay and COBRA studies (EasyWay Cooperative Systems Task Force, 2012; TNO, 2013). When roadside units reach the end of their lifetime, it is assumed that they are replaced for the purposes of the cost-benefit analysis.

New roadside ITS sub-systems

Business model

It is assumed that the cost of deploying, running and maintaining new roadside ITS sub-systems is assigned to relevant highways agencies. Deployments are made to stretches of different road types at a rate determined by the various deployment scenarios, with one new roadside unit required per 1km of inter-urban road. This distance is greater than that stated in the COBRA and EasyWay studies (TNO, 2013; EasyWay Cooperative Systems Task Force, 2012) but was agreed with industry experts (during a teleconference held with relevant WG1 members on 12th October 2015) as a more appropriate figure to use given recent technological advances. Each roadside unit is assumed to be compatible with all the C-ITS service bundles deployed, with no additional costs associated with adding additional services.

All costs associated with integrating roadside ITS sub-systems into central traffic management centres (TMCs) and with local traffic controllers, or for providing software and applications allowing end-users to access the V2I services that they facilitate, are dealt with separately in the central, personal and in-vehicle ITS sub-system categories.

Summary of inputs to the cost-benefit analysis

A summary of the key assumptions and inputs to the cost-benefit analysis for new roadside infrastructure is shown in Box B-10 below. A full breakdown of costs is given in Table B-23. The following sections discuss these aspects in more detail.

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33 USD/EUR Exchange rate of 0.7781 (January 2012 – December 2012 period average) Source: www.oanda.com/currency/historical-rates/

34 COBRA assumes one roadside ITS sub-system every 300m and states “the upper bound on range is normally quoted as 1000m based on the latency requirements, but 300m allows a higher bit rate and a more reliable connection to be achieved, and this is the range often quoted.”
Box B-10. Summary of key assumptions and inputs to the cost-benefit analysis for new roadside infrastructure

Key assumptions:

- New roadside ITS sub-systems only relevant to inter-urban areas, with a growing percentage of different road types equipped in the scenarios. This is not the case in the 'high' sensitivity, where no inter-urban roadside infrastructure is required due to the near-ubiquitous coverage provided by cellular networks – which are assumed to provide all V2I services in the 'high' sensitivity.
- One new system is required per 1km of road equipped.
- New roadside ITS sub-systems have an additional power consumption of 30 – 50 W.
- Central ITS sub-system integration costs and software application development costs accounted for separately in Section B.2.4.4.
- New roadside ITS sub-system lifetime: 10 years.

Table B-23. Breakdown of costs for new roadside units

<table>
<thead>
<tr>
<th>Cost item</th>
<th>Input</th>
<th>Year</th>
<th>Cost owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upfront costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment/hardware</td>
<td>€6,616.79</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Installation/mounting</td>
<td>€7,500.00</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Ongoing costs (per year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular maintenance</td>
<td>5%</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Power consumption</td>
<td>€42.05</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Data</td>
<td>€200.56</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
<tr>
<td>Secure communications</td>
<td>€37.91</td>
<td>2015</td>
<td>Highways Agency</td>
</tr>
</tbody>
</table>

Upfront costs

The total upfront cost to install a new roadside unit to be capable of delivering C-ITS functionality has been estimated to be **€14,116.79** based on a literature review and discussions with industry experts during a teleconference held with relevant WG1 members on 12th October 2015. This is composed of:

- An equipment/hardware cost: Installation of new base units in areas without previous roadside infrastructure is expected to be more costly than upgrading existing roadside units. The equipment cost for a new roadside ITS sub-system with traffic monitoring sensors is estimated to cost **€6,000**, as reported in the EasyWay, COBRA studies (EasyWay Cooperative Systems Task Force, 2012; TNO, 2013). This cost was broadly in the range suggested by industry experts and other EU studies such as SAFESPOT (BASt et al., 2010).
- Installation and mounting costs, which will vary depending on the complexity of installation. Research shows that a number of activities are typically required for RSU installation and that costs will be highly site (and possibly Member State) dependent. A report issued by the US DoT (NHTSA, 2014) suggests that in addition to equipment and installation costs, the following activities must be considered:
  - Radio survey per site – to determine optimum placement of the ITS-G5 radio and antenna for maximum coverage.
o Map / GID generation – to accurately map the road layout, especially at intersections
o Planning – estimated to be 5% of total cost
o Design – costs related to installation of RSUs in each location
o System integration and licence – administration costs associated with the new RSU
o Traffic control – during installation of the unit, including any safety signage

Industry experts suggest that a simple installation including the above may cost €3,000, whereas a more complex installation would be in the region of €12,000. An average value of €7,500 has been assumed. For reference, an installation cost of €10,000 was assumed in the EasyWay project (EasyWay Cooperative Systems Task Force, 2012).

**Ongoing costs**

The annual ongoing cost per roadside unit is broken down into:

- Regular maintenance is assumed to be 5% of the capital cost per year. Several studies have cited this percentage for maintenance, such as the COBRA study and US focussed NHTSA US DoT Connected Vehicle Field Infrastructure Footprint Analysis (TNO, 2013; NHTSA, 2014). Regular maintenance will include activities such as realigning the antennas, rebooting hardware, checking system operational status and other routine checks (NHTSA, 2014).

- Power consumption: WG1 members advised that power consumption required for new roadside ITS sub-systems would be in the range of 30 – 50 W. Using a power consumption of 40 W and the second half of 2014 EU industrial average electricity price of €0.12 per kWh, leads to an annual cost of €42.05 per year per roadside unit (Eurostat, 2015).

- Data costs, which were based on the COBRA study and were calculated to be €200 per year, per new roadside ITS sub-system (TNO, 2013).

- Secure communications: An extensive study was carried out by the US DoT to assess the cost of secure communications. It assumes that a security credentials management system will need to be developed and implemented (most likely by a private company) and suggests an annual cost of $50 per roadside unit to keep security credentials up to date (NHTSA, 2014). This is equivalent to €37.68 per year.  

**Lifetime**

A lifetime of 10 years has been assumed for roadside ITS sub-systems. This is in keeping with the EasyWay and COBRA studies (EasyWay Cooperative Systems Task Force, 2012; TNO, 2013). When roadside units reach the end of their lifetime, it is assumed that they are replaced for the purposes of the cost-benefit analysis.
B.3 References


Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Annex C – Modelling results from two Deployment Scenarios
Report for DG MOVE
Customer:
DG MOVE

Customer reference:
MOVE/B4/SER/2016-239/S12.762019

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Ricardo reference:
Ref: ED10644  Issue number 5

In November 2012, Ricardo plc acquired the assets and goodwill of AEA Technology plc and formed a new company, Ricardo-AEA Ltd. The entire capability and resources previously represented by AEA Technology plc were transferred to Ricardo-AEA, as were all employees. Consequently, where specific projects or track record referenced in this proposal were undertaken and completed prior to the acquisition, for contractual reasons, these continue to be identified as AEA Technology plc.
C. ANNEX C – MODELLING RESULTS FROM TWO DEPLOYMENT SCENARIOS

C.1. Design principle for Deployment Scenarios

In addition to the three policy options, two deployment scenarios have been developed that go beyond the strongest policy option to assess possibilities for enhanced C-ITS and vary in rate and scope of deployment. These deployment scenarios should explore possible (additional) measures to enable accelerated deployment of C-ITS.

The aim of the deployment scenarios is to quantitatively assess the impacts of aspirational levels of future C-ITS deployment beyond Day 1 services and to discuss how these levels could be achieved over and above Policy Option 3 (PO3). The rate and scope of deployment builds on that defined in PO3 and is differentiated between the deployment scenarios through providing a high-level overview of possible (additional) measures to enable accelerated deployment of C-ITS beyond what is considered under PO2 and PO3. Such measures include:

- The addition of Day 1.5 C-ITS services building on the Day 1 services included in PO1-3. The increase of types of C-ITS services would require additional harmonized service profiles to be added to the specifications.
- Requirements for minimum infrastructure provision on certain road types.
- EU funding for increased infrastructure funding for example through the Connecting Europe Facility.
- Increased R&D funding to accelerate the commercialisation of certain pre-commercial C-ITS services.

The narrative behind each of the additional deployment scenarios has been developed at a high level and impacts are not assessed to the same level of detail as for the policy options. Rather, these scenarios are designed to provide an overview of the impacts of possible future widespread deployment of C-ITS across the EU and how this might be achieved. The high-level narrative around the additional deployment scenarios is described below:

a) Deployment Scenario 1 (DS1): In DS1, it is assumed that the scope of the specifications is broadened to include all Day 1 and Day 1.5 services. The other measures included in PO3 remain unchanged. Deployment of roadside C-ITS stations for V2I services remains unchanged relative to PO3.

b) Deployment Scenario 2 (DS2): In DS2, the scope of deployment remains the same as in DS1, however an accelerated uptake in roadside infrastructure is assumed.

See also Table C-1 for further detail on the differences between Deployment Scenarios 1 and 2.

Apart from uptake rates and scope of uptake, all other assumptions and input data (i.e. on impacts, costs) are kept the same for the Deployment Scenarios.
Table C-1: Scenario overview showing the sequential progression in the headline assumptions between deployment scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>New vehicles</td>
</tr>
<tr>
<td><strong>Deployment Scenario 1</strong></td>
<td>PO3 + extension of scope to Day 1.5 services (Bundles 4, 5, 7)</td>
<td>Deployment of all Bundles across all vehicles</td>
</tr>
<tr>
<td><strong>Deployment Scenario 2</strong></td>
<td>DS1 + accelerated infrastructure uptake</td>
<td></td>
</tr>
</tbody>
</table>

C.2. Uptake rates and scope for Deployment Scenarios

For the uptake in new vehicles, the deployment assumptions can be split out into further detail (see Table C-2). The base assumptions regarding model life cycles for different vehicle types stay the same as in the baseline and the policy options.

Table C-2: Deployment Scenarios – uptake assumptions – New vehicles

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>DS1</th>
<th>DS2</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Transport</td>
<td>Uptake rates reflect mandate, reaching all cars in one full model cycle, starting in 2021.</td>
<td></td>
<td>Cars assumed to have model life cycle of 7 years and facelift cycles of 4 years. Public transport &amp; freight transport assumed to have longer full model life cycle of 9 years and facelift cycles of 5 years.</td>
</tr>
<tr>
<td>Public Transport</td>
<td>All vehicles covered by 2030, starting 2021 (1 full model cycle).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>All vehicles covered by 2030, starting 2021 (1 full model cycle).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As Figure C-1 shows, the uptake rates for DS1 and DS2 in new vehicles are the same as for PO3, the variance between the scenarios only comes in through the scope and the infrastructure uptake. Figure C-2 shows how the scope in terms of C-ITS services expands from the policy options to cover all Day 1.5 services in the deployment scenarios.
Figure C-1: Uptake in new vehicles across all scenarios

![Graph showing uptake in new personal vehicles across scenarios from 2015 to 2035.]

Figure C-2: Matrix for DS1 and DS2

<table>
<thead>
<tr>
<th>Bundle of services</th>
<th>TEN-T Corridors</th>
<th>TEN-T Core</th>
<th>Other Motorways</th>
<th>Other Interurban Roads</th>
<th>Urban</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bundle 1</strong> Day 1 V2V - safety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V Personal transport</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>Emergency brake light, Emergency vehicle approaching, Slow or stationary vehicle(s), Traffic jam ahead warning, Hazardous location notification</td>
</tr>
<tr>
<td>Public transport</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td></td>
</tr>
<tr>
<td><strong>Bundle 2</strong> Day 1 V2I (mainly applicable to motorways)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I Personal transport</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>Road works warning, Weather conditions, In-vehicle signage, In-vehicle speed limits, Probe vehicle data, Shockwave damping</td>
</tr>
<tr>
<td>Public transport</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td>POs</td>
<td></td>
</tr>
<tr>
<td><strong>Bundle 3</strong> Day 1 V2I (mainly applicable to urban areas)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I Personal transport</td>
<td>POs</td>
<td>POs</td>
<td></td>
<td></td>
<td></td>
<td>GLOSA/TGS, Signal violation/intersection safety, Traffic signal priority request by designated vehicles</td>
</tr>
<tr>
<td>Public transport</td>
<td>POs</td>
<td>POs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>POs</td>
<td>POs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bundle 4</strong> Day 1.5 V2I - Parking information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I Personal transport</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>Off-street parking information, On-street parking management and information, Park &amp; Ride information, Information on fuelling &amp; charging stations for AFVs</td>
</tr>
<tr>
<td>Public transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td></td>
</tr>
<tr>
<td><strong>Bundle 5</strong> Day 1.5 V2I - Traffic information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I Personal transport</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>Traffic information &amp; smart routing</td>
</tr>
<tr>
<td>Public transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td></td>
</tr>
<tr>
<td><strong>Bundle 7</strong> Day 1.5 V2X (mainly applicable to urban areas)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X Personal transport</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td>DS1/DS2</td>
<td></td>
<td></td>
<td>Vulnerable road user protection</td>
</tr>
<tr>
<td>Public transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Colour coding key:**
- Highly applicable
- Applicable
- Applicable but limited benefits
- Few benefits
- Not relevant in this environment
For **Personal ITS devices**, as per the baseline, uptake in smartphones will start when vehicle penetration in new vehicles starts. From the start year for new vehicle penetration, the Personal ITS devices uptake increases linearly, to the max uptake (95%) when in-vehicle systems reach 100%.

Regarding infrastructure uptake, a differentiation by country grouping is required. Table C-3 gives an overview of the uptake assumptions for Front Runners across all road types. The rationale for building up uptake across the different road type and country groupings are the same as in the policy options, however, accelerations in uptake are assumed. DS1 shows the same uptake rates and scope as PO3. The difference between those scenarios comes from an extension of the scope regarding in-vehicle uptake to include Day 1.5 services. In DS2, there is no difference in scope compared to DS1 but a further increase in deployment in infrastructure.

**Table C-3: Deployment Scenarios – uptake assumptions for infrastructure in Front Runners**

<table>
<thead>
<tr>
<th>Road type</th>
<th>DS1 (same as PO3)</th>
<th>DS2</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEN-T Corridor</td>
<td>RSU: Use actual data on average deployment levels expected to be achieved by 2020. From 2021, project the trajectory at 150% of the deployment rate between 2015 and 2020, triggered by the in-vehicle mandate. Cellular: assume 84% coverage</td>
<td>RSU: Use actual data on average deployment levels expected to be achieved by 2020. From 2021, project the trajectory at 200% of the deployment rate between 2015 and 2020, triggered by the requirements for minimum infrastructure provision and additional funding. Cellular: assume 84% coverage</td>
<td>-</td>
</tr>
<tr>
<td>TEN-T Core</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Motorways</td>
<td>RSU: From 2021, project at 50% of the uptake rate on TEN-T Corridor and Core roads. Cellular: assume 84% coverage.</td>
<td>RSU uptake applied to wider network is based on reduced rates relative to TEN-T Corridor/Core uptake.</td>
<td></td>
</tr>
<tr>
<td>Other Interurban Roads</td>
<td>RSU: From 2021, project at 25% of the uptake rate on TEN-T Corridor and Core roads. Cellular: assume 84% coverage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>RSU: 8% (traffic light stock that is replaced each year) x 75% (new traffic lights equipped) per year from 2020.</td>
<td>RSU: 8% (traffic light stock that is replaced each year) x 100% (new traffic lights equipped) per year from 2020.</td>
<td>In urban areas, % of new traffic lights equipped with C-ITS transmitters beyond 2020 increases from DS1 to DS2. Urban infrastructure deployment based on 12.5-year traffic light lifetime.</td>
</tr>
</tbody>
</table>
Table C-4 gives an overview of the uptake assumptions for Planned Adopters and Followers. By assumption EU intervention would be designed to provide a level playing field for all European countries, so the uptake rates for these country groups are expected to be the same as for Front Runners, however, the uptake start dates in some road types are delayed by 2 and 4 years for Planned Adopters and Followers respectively.

Table C-4: Deployment Scenarios – Uptake assumptions for infrastructure in Planned Adopters and Followers

<table>
<thead>
<tr>
<th>Road type</th>
<th>DS1 (same as PO3)</th>
<th>DS2</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEN-T Corridor</td>
<td>RSU: Use actual data on average deployment levels expected to be achieved by 2020 and projected to 2021. From 2021, the uptake follows the same trend as the TEN-T roads in Front Runners in the given scenario, i.e. reflecting the requirements for minimum infrastructure provision. Cellular: assume an 84% coverage</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>TEN-T Core</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Motorways</td>
<td>RSU: Uptake follows the same uptake trend as the Other Motorways and Other Interurban Roads in Front Runners in the given scenario, with an uptake start date delayed by 2 and 4 years for Planned Adopters and Followers respectively. Cellular: assume an 84% coverage</td>
<td>RSU uptake applied to wider network at reduced rates relative to TEN-T Corridor/Core uptake.</td>
<td></td>
</tr>
<tr>
<td>Other Interurban</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>RSU: Uptake follows the same uptake trend as the Urban roads in Front Runners in the given scenario, with an uptake start date delayed by 2 and 4 years for Planned Adopters and Followers respectively. Cellular: assume an 84% coverage</td>
<td>In urban areas, % of new traffic lights equipped with C-ITS transmitters beyond 2020 increases from DS1 to DS2. Urban infrastructure deployment based on 12.5-year traffic light lifetime.</td>
<td></td>
</tr>
</tbody>
</table>

Looking at the infrastructure uptake across the TEN-T Core/Corridor roads, Figure C-3 shows how the above described uptake assumptions translate into uptake rates over time for TEN-T Core/Corridor roads.
For urban roads the uptake over time for all scenarios and country groupings is displayed in Figure C-4.

**Figure C-4: Infrastructure uptake rates across all scenarios and all country groupings for urban roads**
C.3. Results for Deployment Scenarios

As previously discussed, the Deployment Scenarios start from and go beyond Policy Option 3 in terms of deployment rates and scope of deployment. While Deployment Scenario 1 explores the addition of Day 1.5 C-ITS services, Deployment Scenario 2 in addition considers an acceleration in infrastructure uptake. In the following sections the economic, social and environmental impacts will be summarised for the two Deployment Scenarios. Policy Option 3 results will also be displayed for comparison.

C.3.1. Economic impacts

A key factor to assess the economic impacts are the technology investment costs over time. Figure C-5 shows the total annual deployment of in-vehicle C-ITS services which is the same for Policy Option 3, Deployment Scenario 1 and 2. From 2019 onwards there is a steep increase in new vehicle deployment.

Figure C-5: Total cumulative new vehicle deployment relative to baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28

In terms of equipment of existing vehicles through personal ITS devices, the uptake is steep in the early years, however, reaches a maximum in 2028 (see Figure C-6). After that a linear decrease can be observed until 2035. The maximum observed is in line with the point at which 100% of new vehicles are equipped. After that, no additional vehicles are being equipped and retrofitted vehicles (via personal ITS devices) slowly leave the vehicle fleet through the natural turnover of the total fleet.
The table below shows the cumulative in-vehicle deployment in these scenarios split by new vehicles equipped and retrofitting of existing vehicles through personal ITS devices.

**Table C-5: Cumulative total in-vehicle deployment relative to the baseline for PO3, DS1 and DS2 – EU28**

<table>
<thead>
<tr>
<th>New/existing vehicles equipped</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total number</td>
<td>% of fleet of 323 million</td>
</tr>
<tr>
<td>PO3, DS1 and DS2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New vehicles equipped</td>
<td>79 mn</td>
<td>24%</td>
</tr>
<tr>
<td>Existing vehicles equipped</td>
<td>117 mn</td>
<td>36%</td>
</tr>
<tr>
<td>through personal ITS devices</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For infrastructure deployment the uptake rates between the Deployment Scenarios are different by design. Uptake rates for Deployment Scenario 1 is the same as for Policy Option 3. Deployment Scenario 2 on the other hand shows an accelerated uptake from 2019. As Figure C-7 shows, the infrastructure uptake for upgraded RSUs in 2035 is almost 30% higher for Deployment Scenario 2 compared to Policy Option 3 and Deployment Scenario 1.
The picture for new RSU deployment is very similar, as Figure C-8 shows.

For both scenarios and Policy Option 3, cumulative total infrastructure deployment is summarised in the below table.
Table C-6: Cumulative infrastructure (RSU) deployment relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3 / Deployment Scenario 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrastructure upgrades</td>
<td>71,000</td>
<td>142,000</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New infrastructure deployment</td>
<td>101,000</td>
<td>184,000</td>
</tr>
</tbody>
</table>

*Note: Numbers are rounded to the thousand*

When looking at the total additional annual equipment costs (covering all costs equipment costs i.e. in-vehicle systems, personal ITS devices, RSU upgrades/new and central ITS subsystems) relative to the baseline (see Figure C-9) Deployment Scenario 1 follows the curve of Policy Option 3. Deployment Scenario 2 on the other hand shows slightly higher equipment costs, due to additional infrastructure deployment. In comparison to the in-vehicle costs, these are, however, marginal.

Figure C-9: PV cumulative additional equipment costs relative to baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28
The cumulative additional equipment costs relative to the baseline are summarised in the below table for 2030 and 2035.

**Table C-7: PV cumulative additional equipment costs relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Policy Option 3 / Deployment Scenario 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-vehicle systems (new)</td>
<td>€14,406 mn</td>
<td>€23,625 mn</td>
</tr>
<tr>
<td>Personal ITS devices (retrofit)</td>
<td>€4,836 mn</td>
<td>€5,864 mn</td>
</tr>
<tr>
<td>Infrastructure (RSU) - upgrades</td>
<td>€251 mn</td>
<td>€438 mn</td>
</tr>
<tr>
<td>Infrastructure (RSU) – new</td>
<td>€955 mn</td>
<td>€1,527 mn</td>
</tr>
<tr>
<td>Central ITS systems</td>
<td>€621 mn</td>
<td>€886 mn</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>€21,070 mn</strong></td>
<td><strong>€32,340 mn</strong></td>
</tr>
</tbody>
</table>

| **Deployment Scenario 2** | | |
| In-vehicle systems (new) | €14,406 mn | €23,625 mn |
| Personal ITS devices (retrofit) | €4,836 mn | €5,864 mn |
| Infrastructure (RSU) - upgrades | €360 mn | €602 mn |
| Infrastructure (RSU) – new | €1,188 mn | €1,879 mn |
| Central ITS systems | €621 mn | €886 mn |
| **Total** | **€21,411 mn** | **€32,856 mn** |

A key benefit from some Day 1.5 C-ITS services (e.g. smart routing) is an improvement of traffic efficiency which results in time savings. With greater penetration the benefits increase over time reaching more than €50 billion per year in 2035 for Deployment Scenario 1 (see Figure C-10). For Deployment Scenario 2 the urban travel time savings benefit is even higher due to a higher infrastructure penetration. In both cases this is a significant increase in time savings from Policy Option 3. As the chart below shows there is a kink in the additional annual urban travel time savings in 2025 reflecting the year when Day 1.5 services come in, which have significant impacts.
The additional annual urban travel time savings in monetary terms are shown in Table C-8.

Table C-8: Total additional annual monetary urban travel time savings relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>€3.5 bn</td>
<td>€10.1 bn</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>€25.3 bn</td>
<td>€47.2 bn</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>€33.2 bn</td>
<td>€55.7 bn</td>
</tr>
</tbody>
</table>

In terms of the monetary benefits of cumulative urban travel time savings compared to the baseline, the table below compares the two scenarios against Policy Option 3.

Table C-9: PV monetary benefits of cumulative urban travel time savings relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>€7.7 bn</td>
<td>€28.2 bn</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>€67.6 bn</td>
<td>€173.6 bn</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>€89.3 bn</td>
<td>€218.2 bn</td>
</tr>
</tbody>
</table>

Further cost savings from C-ITS are expected though fuel consumption savings. Figure C-11 shows the annual fuel consumption savings relative to the baseline. As the figure shows the annual additional benefits from fuel consumption reduction stagnates from 2030 onwards but additional benefits remain prominent. For Policy Option 3 a slight drop can be observed after 2030 which reflects that the slope for fuel consumption reductions in Policy Option 3 is less steep than for the baseline from 2030 onwards, though the total annual fuel consumption is significantly lower.
The present value of additional annual benefits due to reduced fuel consumption in monetary terms are shown in Table C-10.

Table C-10: Total additional annual monetary benefits from fuel consumption reductions relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>€2.9 bn</td>
<td>€3.4 bn</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>€5.2 bn</td>
<td>€6.5 bn</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>€5.9 bn</td>
<td>€7.2 bn</td>
</tr>
</tbody>
</table>

In terms of the monetary benefits of cumulative fuel consumption reductions compared to the baseline, the table below compares the two scenarios against Policy Option 3.

Table C-11: PV monetary benefits of fuel consumption reductions relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020–2030</th>
<th>2020–2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>€9.2 bn</td>
<td>€18.2 bn</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>€16.5 bn</td>
<td>€33.1 bn</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>€18.3 bn</td>
<td>€36.9 bn</td>
</tr>
</tbody>
</table>
**C.3.2. Road safety impacts**

As Figure C-12 shows, the number of annually avoided accidents increases over time and amounts to 165 thousand in 2035 for Deployment Scenario 1. For Deployment Scenario 2 the number is even higher with 185 thousand.

**Figure C-12: Total annual accidents avoided relative to baseline Policy Option 3, Deployment Scenario 1 and 2 – EU28**

In terms of total annual additional accidents avoided, the table below compares the two deployment scenarios against Policy Option 3.

**Table C-12: Total additional annual avoided accidents relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>114,000</td>
<td>153,000</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>128,000</td>
<td>165,000</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>148,000</td>
<td>185,000</td>
</tr>
</tbody>
</table>

In terms of the monetary benefits of cumulative accidents avoided compared to the baseline, the table below compares the two scenarios against Policy Option 3.

**Table C-13: PV monetary benefits of cumulative total accidents avoided relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>€38.0 bn</td>
<td>€76.9 bn</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>€44.1 bn</td>
<td>€86.4 bn</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>€50.0 bn</td>
<td>€97.9 bn</td>
</tr>
</tbody>
</table>
C.3.3. Environmental impacts

Annual CO$_2$ emission reductions compared to the baseline are presented in Figure C-13. The savings in terms of CO$_2$ emissions in 2035 compared to the baseline reach 19 million tonnes for Deployment Scenario 1 and 21 million tonnes for Deployment Scenario 2.

Figure C-13: Total annual CO2 decrease relative to baseline Policy Option 3, Deployment Scenario 1 and 2 – EU28

In terms of additional CO$_2$ emissions avoided, the table below compares the two deployment scenarios against Policy Option 3.

Table C-14: Total additional annual CO2 emissions [1,000 tonnes] avoided relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>9,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>15,000</td>
<td>19,000</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>17,000</td>
<td>21,000</td>
</tr>
</tbody>
</table>

In terms of the monetary benefits of cumulative CO$_2$ emissions avoided compared to the baseline, the table below compares the two scenarios against Policy Option 3.

Table C-15: PV monetary benefits of cumulative total CO2 emissions avoided relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>€2.8 bn</td>
<td>€5.3 bn</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>€4.9 bn</td>
<td>€9.6 bn</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>€5.4 bn</td>
<td>€10.7 bn</td>
</tr>
</tbody>
</table>
The additional annual pollutant emissions (PM, NOx, VOC) are shown in Table C-16. Most pollutants show a reduction of emissions compared to the baseline, for PM emissions however, a negative development can be observed. This is in line with the observations from the policy options. As the below table shows, the additional annual pollutant emissions avoided for NOx and VOC decreases between 2030 and 2035, apart from VOC in Policy Option 3.

Table C-16: Additional annual pollutant emissions avoided [tonnes] relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>-290</td>
<td>-240</td>
</tr>
<tr>
<td>NOx</td>
<td>4810</td>
<td>4420</td>
</tr>
<tr>
<td>VOC</td>
<td>760</td>
<td>890</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>-460</td>
<td>-610</td>
</tr>
<tr>
<td>NOx</td>
<td>5690</td>
<td>4640</td>
</tr>
<tr>
<td>VOC</td>
<td>1400</td>
<td>1350</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>-500</td>
<td>-690</td>
</tr>
<tr>
<td>NOx</td>
<td>6660</td>
<td>5200</td>
</tr>
<tr>
<td>VOC</td>
<td>1660</td>
<td>1540</td>
</tr>
</tbody>
</table>

In terms of cumulative emissions savings in monetary terms for all pollutant emissions, the table below compares these for the deployment scenarios and Policy Option 3 in 2030 and 2035.

Table C-17: PV monetary benefits of cumulative total pollutant emissions avoided relative to the baseline – Policy Option 3, Deployment Scenario 1 and 2 – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>€156 mn</td>
<td>€292 mn</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>€182 mn</td>
<td>€288 mn</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>€212 mn</td>
<td>€338 mn</td>
</tr>
</tbody>
</table>

C.3.4. Overall comparison

Comparing both Deployment Scenarios and Policy Option 3 overall shows that in terms of total annual costs relative to the baseline the three scenarios perform similarly. These costs represent equipment costs. Cost increase over time until 2028 (see Figure C-14). After that further costs are observed but less so once uptake in the fleet is widespread.
Cumulative costs for the scenarios are displayed below for 2030 and 2035.

**Table C-18: PV cumulative total costs by scenario relative to the baseline – EU28**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>-€21.1 bn</td>
<td>-€32.3 bn</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>-€21.1 bn</td>
<td>-€32.3 bn</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>-€21.4 bn</td>
<td>-€32.9 bn</td>
</tr>
</tbody>
</table>

The total annual benefits relative to the baseline increase steadily over time, reaching a total of €72 billion for Deployment Scenario 1 in 2035 (see Figure C-15). For Deployment Scenario 2 the benefits are higher with €84 billion by 2035. These benefits are significantly higher than those of Policy Option 3.
Cumulative total benefits are displayed in Table C-19 for 2030 and 2035 for the three scenarios.

Table C-19: PV cumulative total benefits by scenario relative to the baseline – EU28

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020-2030</th>
<th>2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy Option 3</td>
<td>€58 bn</td>
<td>€129 bn</td>
</tr>
<tr>
<td>Deployment Scenario 1</td>
<td>€133 bn</td>
<td>€303 bn</td>
</tr>
<tr>
<td>Deployment Scenario 2</td>
<td>€163 bn</td>
<td>€364 bn</td>
</tr>
</tbody>
</table>

To summarise, the addition of Day 1.5 services under DS1 leads to a very significant increase in benefits compared to PO3. Table C-20 below summarises the overall comparison between the deployment scenarios and Policy Option 3.

The additional benefit is greatest for urban travel time savings, with a 516% increase in DS1 from PO3 and a 675% increase in DS2 from PO3, due to the additional C-ITS services considered in Day 1.5 services. Many of these services help drivers save time, by providing information on parking availability or enhanced traffic routing. As a result of these time saving services, the deployment scenarios also provide significant fuel consumption and CO2 emissions savings. Finally, there is moderate improvement in accident costs, chiefly due to the addition of Vulnerable Road User (VRU) Protection services.
Table C-20: Summary comparison of PO3 and deployment scenario 2020-2035 benefits relative to the baseline – EU28

<table>
<thead>
<tr>
<th></th>
<th>Policy Option 3</th>
<th>Deployment Scenario 1</th>
<th>% Change from PO3</th>
<th>Deployment Scenario 2</th>
<th>% Change from PO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidents</td>
<td>€76.9 bn</td>
<td>€86.4 bn</td>
<td>12%</td>
<td>€97.9 bn</td>
<td>27%</td>
</tr>
<tr>
<td>Urban Travel Time</td>
<td>€28.2 bn</td>
<td>€173.6 bn</td>
<td>516%</td>
<td>€218.2 bn</td>
<td>675%</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>€18.2 bn</td>
<td>€33.1 bn</td>
<td>82%</td>
<td>€36.9 bn</td>
<td>102%</td>
</tr>
<tr>
<td>CO2 Emissions</td>
<td>€5.3 bn</td>
<td>€9.6 bn</td>
<td>81%</td>
<td>€10.7 bn</td>
<td>102%</td>
</tr>
<tr>
<td>Pollutants</td>
<td>€0.3 bn</td>
<td>€0.3 bn</td>
<td>-2%</td>
<td>€0.3 bn</td>
<td>16%</td>
</tr>
<tr>
<td><strong>Total Benefits</strong></td>
<td><strong>€128.9 bn</strong></td>
<td><strong>€302.9 bn</strong></td>
<td><strong>135%</strong></td>
<td><strong>€364.0 bn</strong></td>
<td><strong>182%</strong></td>
</tr>
<tr>
<td><strong>Total Costs</strong></td>
<td><strong>€32.3 bn</strong></td>
<td><strong>€32.3 bn</strong></td>
<td><strong>0%</strong></td>
<td><strong>€32.9 bn</strong></td>
<td><strong>2%</strong></td>
</tr>
<tr>
<td><strong>Net Benefits</strong></td>
<td><strong>€96.5 bn</strong></td>
<td><strong>€270.5 bn</strong></td>
<td><strong>180%</strong></td>
<td><strong>€331.1 bn</strong></td>
<td><strong>243.0%</strong></td>
</tr>
</tbody>
</table>
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Annex D – National and Deployment Case Studies
Report for DG MOVE
In November 2012, Ricardo plc acquired the assets and goodwill of AEA Technology plc and formed a new company, Ricardo-AEA Ltd. The entire capability and resources previously represented by AEA Technology plc were transferred to Ricardo-AEA, as were all employees. Consequently, where specific projects or track record referenced in this proposal were undertaken and completed prior to the acquisition, for contractual reasons, these continue to be identified as AEA Technology plc.
D. ANNEX D: NATIONAL AND DEPLOYMENT CASE STUDIES

D.1. CASE STUDY: C-Roads Platform

D.1.1. Introduction

D.1.1.1. Background

The C-Roads Platform was formed in 2016 to provide a single point of contact for cooperation between the automotive industry OEMs and European Member States. Initially, 8 Member States were included in the C-Roads Platform, but this number increased to 16 as of October 2017 (C-Roads, ND).

D.1.1.2. Objectives

The C-Roads Platform aims to facilitate harmonised and interoperable C-ITS deployment across the EU. The Platform adopts a technology neutral position, and hopes to achieve C-ITS services that are interoperable across all Member States. The projects under the C-Roads Platform are implemented by Member State beneficiaries, with the Platform encouraging cooperation and harmonisation between the projects.

D.1.2. Views on proposed Delegated Regulation on C-ITS

D.1.2.1. Problem definition

Martin Bohm was mostly happy with the problem definition we have defined. His main concern was that there is no single business model for a single stakeholder for C-ITS services. V2I C-ITS needs a shared business model that addresses the needs of the OEMs who have to invest in vehicle technology, and the infrastructure operators who have to invest in C-ITS stations and equipment.

The need for a shared business model raises challenges in cooperation between the different stakeholders. Each stakeholder group should trust the other to deploy the relevant technologies, but if any stakeholder does not deploy their part of the service then the whole system does not work. This can result in stranded investments, which will be a significant problem for the stakeholders who have deployed C-ITS services. Infrastructure operators have historically delivered services directly to the end users (cars, cyclists or pedestrians), but are now required to work with the vehicle manufacturers who will provide a link to the user.

Martin also noted that the business case must be proven on a wider geographical scale than current deployment projects. Pre-commercial deployment projects need to be larger scale than the current projects, otherwise the case for EU-level deployment has not been shown. This must be done by both the OEMs and infrastructure operators. Martin suggested that the objective of producing a large-scale pre-commercial/business model should be added to the objectives.

Another complexity raised by Martin is the difference in business models between infrastructure operators and OEMs. Infrastructure is being provided for the benefit of everyone on the road, while the vehicle is sold to an individual. For example, navigation systems in vehicles will aim to provide the best route for an individual, while the transport management system tries to provide the best routes for everyone.
D.1.2.2. Security

Measures discussed for addressing security issues in the Delegated Act include:
- Guidance on Security and Certificate policy
- Definition of Security and Certificate policy in specifications
- Mandate Security and Certificate policy
- Definition of operational functions and governance roles in specifications

The C-Roads Platform has a dedicated task force to deal with security issues. A report was due to be published by this task force at the end of January 2018, describing how security should be implemented in C-ITS\(^1\). The task force has collected information on security implementation from the various Member States involved in the Platform. Security is not currently perceived as a core topic for deployment, but is part of the wider C-ITS discussion.

In December 2017, the C-Roads Platform security policy was accepted by all the experts involved, and they agreed that there should be a central authority for handling all the security keys for C-ITS. Martin noted that this authority will likely be DG JRC as they are considered a neutral partner, which is essential for security matters.

Martin also noted that security is closely linked to privacy, certification and assessment. Security keys will not ensure that the C-ITS stations and vehicles are prepared to deal with security issues. The C-Roads Platform is focusing on ensuring that the infrastructure is secure, while also discussing the vehicle side with the V2V Communications Consortium to ensure both stakeholder groups are developing in parallel and are interoperable with each other.

The C-Roads Platform aimed to harmonise policy at a European level, by creating policy statements and position papers. There are sometimes conflicting messages from the different Member States, and the Platform aims to bring these together to present a unified approach. If necessary, policy statements can be prepared by the C-Roads Platform addressing all stakeholders – public and private.

Martin was supportive of mandating security and certificate policies, but that the definition of operational functions and governance roles in the specifications should be adopted with this. The definition needs to clearly define who is responsible for carrying out the actions required. Given the diverse views between stakeholders, Martin considered a mandate to be the best route.

Martin noted that the EU C-ITS Platform has adopted a security policy\(^2\), but that it now must be translated for infrastructure operators and OEMs. The EU C-ITS Platform has a wide range of stakeholder types, and the policy must be further detailed for deployment and procurement. Martin felt that the policy should be broken down into technical descriptions, and coordinated with the V2V side to ensure they are interoperable. This issue is unlikely to be fully solved by 2019, but will hopefully be defined enough to plan for future implementation.

Regarding procurement, Martin felt that OEMs and infrastructure operators must foresee the security mechanisms required, even though the keys are not yet in place. The architecture and systems implementation must be prepared now, for use later.

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\(^1\) As of April 2018, this has not been published.

**D.1.2.3. Privacy and protection of personal data**

| Measures considered for addressing privacy and data protection issues in the Delegated Act include: |
| Guidance on protection of personal data and privacy policy by design and by default |
| Include reference to GDPR and e-privacy in specifications |
| Requirement for a Data Protection Impact Assessment (IA) in accordance with the GDPR |
| Definition of principles for the practical implementation of the GDPR in C-ITS in specifications |
| Mandate privacy policy in specifications |
| Mandate privacy IA on C-ITS data controller (art. 35 GDPR) |

Martin noted that in principle the issues of privacy and protection of personal data have hardly any relevance for infrastructure deployment. The infrastructure operators will not be collecting personal data, which will stay with the vehicle. Therefore, it is up to the OEMs to identify which data is private. Martin noted that if the data received from vehicles includes personal data, then they need privacy by design, with the infrastructure removing this data immediately.

However, Martin felt that the C-Roads Platform and infrastructure operators will work with the OEMs to ensure these issues are resolved. The Delegated Acts under the ITS Directive have so far only focused on infrastructure and administration, never on the vehicle. The OEMs need to be given direction, however the ITS Directive may not be the best place for this to happen.

Martin also considered it important to clearly identify which Day 1 services are safety applications to ensure the data for those services is made available. The current thinking is that a user can switch their C-ITS system on or off, giving them the choice of accepting the privacy issues. However, safety critical C-ITS applications should not have this option, and it should be considered whether this needs to be mandated or just guidance provided. The discussion around privacy is still on-going, and this position may change in the future.

The GDPR has already provided a mandate towards privacy, and Martin felt that it is important to ensure that security-critical data is able to be accessed regardless. Without this data, C-ITS does not have a business case. Martin suggested that the Day 1 list of services be split into safety-critical applications which have mandatory requirements to send data, and non-safety-critical applications which can be turned on and off by the driver.
**D.1.2.4. Communication**

| Measures considered for ensuring communication compatibility in the Delegated Act include: |
| Technology neutrality of spectrum use |
| Reference technical standards |
| Embed principles of Annex II of ITS Directive (e.g. interoperability, backward compatibility) |
| Mandate technical standards |
| Functional description of Hybrid Communication in specifications |
| Mandate mature communication technologies (with exception for pilot technologies, cf. EETS Directive) |

The communication technology used was not considered an important topic by Martin. The C-Roads Platform follows a technology neutral position, where whatever technology is available is used for deployment, with the 5.9 GHz frequency band dedicated to safety-related messages. Currently, ITS G5 is the only proven short range communication technology, with some companies looking to make the 5.9 GHz band only accessible to this technology for commercial gain. The allocated frequency band has to be open to any technology, but non-interference of new technologies with existing ones needs to be ensured. Furthermore, interoperability (new technologies need to understand services provided via older technologies) must also be guaranteed, as the frequency band hosts safety critical services.

The C-Roads Platform provides different advice for short and long-range communications, which Martin considered a help in encouraging the large-scale deployment, as different areas might use different communication technologies for service provision. Martin presented the view that C-ITS is about creating a service, and it is not that important who is providing this service to the user as long as core requirements are met. The technology used should consider the needs of the service. For example, safety-critical services should use the technology which is proven and tested, which at this point is short-range communications, but is likely to be complemented by hybrid communications in the longer term.

Martin felt that all the policy options presented above are helpful. He noted that the Delegated Act should not mention specific technologies, and that the different technologies must be able to use the spectrum in parallel with each other. This can be achieved by referencing technical standards and including basic requirements on backward compatibility and interoperability.

Martin considered the option of mandating standards to be too slow, with standardisation processes taking years. C-ITS deployment should begin now, and mandatory standards will slow this process down. Martin also felt that a functional description of the services provided by hybrid communications might be useful, but at this stage would be difficult to create as they are not sure how this communications technology will work in C-ITS. Martin also felt that mandating mature technologies would be helpful to accelerate deployment, but is unlikely to be successful due to stakeholder opposition.
**D.1.2.5. Interoperability**

<table>
<thead>
<tr>
<th>Measures considered for helping to ensure interoperability in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition of technical C-ITS communication profiles in specifications</td>
</tr>
<tr>
<td>Functional description of Day 1 services in specifications</td>
</tr>
</tbody>
</table>

Martin noted that interoperability needs to be achieved in the following ways:

- Interoperability between countries – addressed by the C-Roads Platform.
- Interoperability between operators – shouldn’t be an issue.
- Interoperability between motorway and rural network – addressed at a national level but currently a challenge. This aspect should be included in the Delegated Act to ensure interoperability between the TEN-T network and other roads.
- Interoperability between technologies – addressed by Delegated Act and C-Roads Platform
- Interoperability between services – Day 1 services might be improved in the future, but must retain interoperability with the old versions.

The mistakes made with toll systems that resulted in isolated systems in each country in the EU should be avoided.

Martin considered both options presented above to be useful. The definition of technical C-ITS communication profiles would look different for each technology, and all Day 1 services should be described with both ITS G5 and cellular technologies separately. Future technologies could be added by a further Delegated Act. Adding a functional description of Day 1 services would be helpful to ensure interoperability of services between Member States. The C-Roads Platform are also trying to harmonise this with the C2C Communications Consortium.

**D.1.2.6. Compliance testing**

<table>
<thead>
<tr>
<th>Measures considered for compliance assessment in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition of common minimum requirements for deployment of Day 1 C-ITS services in specifications</td>
</tr>
<tr>
<td>Definition of compliance assessment process for Day 1 C-ITS services in specifications</td>
</tr>
<tr>
<td>Requirement for any new C-ITS station to fulfil the compliance assessment criteria to be part of the C-ITS security trust model</td>
</tr>
<tr>
<td>Ensure backward compatibility of new services and/or technologies with already deployed services</td>
</tr>
<tr>
<td>Ensure consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.</td>
</tr>
</tbody>
</table>

Compliance assessment has not been worked on yet by the C-Roads Platform, however it is considered part of the security and privacy issue. C-ITS stations need to be compliant with the security and privacy policy.

There are currently two suggestions for compliance assessment; self-assessment which is proposed by the OEMs, and certification which is proposed by the Member States. Martin felt that both positions were extremes. He considered the main concern to be ensuring that safety services function well as they are critical systems.
The C2C Communications Consortium are publishing a position paper on this topic in the near future, and the C-Roads Platform might make a proposal once all the information is available. Martin felt that roadside units will require certification, but the vehicle side may be suitable for a self-assessment approach.

Regarding the policy options presented above, Martin was in support of a definition of the common minimum requirements for deployment of Day 1 C-ITS services, and reiterated the need to clearly identify which services are safety-critical and what is required for those services to be successful. He also supported a definition of the compliance assessment process, and noted the importance of ensuring backwards compatibility.

Martin was wary of grouping C-ITS with automated vehicles. The latter is a much more complicated topic, and could slow down progress on C-ITS deployment.

**D.1.2.7. Continuity of services**

<table>
<thead>
<tr>
<th>Measures considered for helping to ensure continuity of services in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Definition of Day 1 services in specifications</td>
</tr>
<tr>
<td>• Functional description of Day 1 services in specifications</td>
</tr>
<tr>
<td>• Reference (prioritise) deployment of Day 1 services</td>
</tr>
<tr>
<td>• Mandate combined deployment of Day 1 services</td>
</tr>
</tbody>
</table>

Martin noted that C-Roads Platform is working on the continuity of services and is currently identifying what Day 1 services each Member State is covering. Road works warnings are being implemented in every C-Roads Member State, with in-vehicle signage being the second most prevalent service.

Martin commented on the difficulty of making services mandatory, as the ITS Directive states that Member States only have to implement the Delegated Acts if the services and data are already available. The framework doesn’t require deployment, but provides rules if deployment is happening.

Martin also suggested that if C-ITS is being deployed, the Delegated Act should include a priority list of C-ITS service deployment. Through this approach, OEMs would know which services are being deployed, and be able to create a strong business case for investing in vehicle technology. Another suggestion was to specify a priority for the services so Member States know where to start. Targeting safety-critical services first might be a useful criterion for such prioritisation. Specifying which services are priority would help new countries to deploy C-ITS by providing a starting point.

Of the options presented above, Martin noted that a definition and functional description of Day 1 services are both supported, as mentioned earlier. Martin also supported prioritising safety-related Day 1 services, with the current list of Day 1 services split into several steps of deployment.
**D.1.2.8. Coordination**

Measures considered for addressing coordination issues in the Delegated Act include:

- Establishment of EU governance bodies (C-ITS governing body, C-ITS supervision body, compliance assessment bodies)
- Establishment of EU policy authorities (privacy policy authority, security policy authority, certificate policy authority)
- Establishment of EU operational bodies (trust list manager, C-ITS point of contact, EU root certification authorities)

The C-Roads Platform currently has a functioning coordination and governance structure for dealing with different Member States. This system is working well and provides a good starting point for developing EU authorities on these matters.

Martin noted that the C-Roads Platform focuses on deployment, but C-ITS needs a more sustainable structure at the European level in the longer term. He was particularly supportive of the establishment of an EU operational body to provide a single point of contact for C-ITS. Having too many bodies could be problematic, so Martin suggested that a good operational body could be established with a governance and policy layer within.

The C-Roads Platform only engages with Member States, but OEMs and operators are now asking to be part of the Platform. They do not have the resources to add these additional tasks to their scope of works. An EU operational body would be able to engage with all stakeholder groups, and begin to consider the impacts for automated vehicles, which will require similar structures in the future.

**D.1.2.9. Enabling environment**

Measures considered for addressing enabling environment issues in the Delegated Act include:

- Policy advice through stakeholder platform
- Programme support action (PSA) under the Connecting Europe Facility (CEF) for the set-up of common EU elements
- Requirements for the exchange of best practice
- Memorandum of Understanding (MoU) in a ‘bottom-up’ approach in which stakeholders could drive activities and initiatives
- Funding for deployment projects
- Funding / coordination of research
- EU deployment coordination
- An agreement on access to selected, specified data for C-ITS services between all relevant public and private stakeholders
- Mandate for standardisation organisations

The C-Roads Platform currently builds on CEF and national funds. One challenge is to ensure that the European Commission continues to co-fund C-ITS deployments after 2020 when the next framework rules start. Member States have so far been willing to cooperate if there is EU funding, but may regress if the funding is withdrawn.

Martin thought that policy advice through a stakeholder platform is an important policy option, but might be better to include as part of the governance structures mentioned above. The requirements for the exchange of best practice, and EU deployment coordination could also be carried out by the operational body.
Regarding the PSA under CEF, Martin thought that issues such as trust, certification, security and new technologies will require something more stable in the long term. These issues cannot be addressed as discrete projects, but need to be provided by a fixed central body coordinating the activities.

Martin felt that the funding should focus on deployment, rather than R&D which can be done after large-scale deployment has been demonstrated. Regarding an agreement on access to data, Martin noted that a previous Delegated Act has already achieved this on the public side, and he questioned if the Delegated Act would be the right place for an agreement on the private side.

**D.1.2.10. Other discussion points**

Martin noted that functional descriptions of the services should be included in all the topics discussed above. For example, in-vehicle speed warnings can be provided by a range of stakeholders, but in order to ensure harmonisation this should be determined. For safety-critical services, Martin felt that the authorities should be the providers.

Along this line of thought, Martin elaborated that there must be the same understanding across the EU as to what the public and private stakeholders are required to do. This could be combined with the idea of splitting up the Day 1 services into deployment packages, with safety-critical services being mandatory for OEMs to provide, while other services can be provided by infrastructure but optionally adopted by the OEMs.

Regarding the impact on SMEs, Martin noted that some road operators are buying resources and knowledge from SMEs, and in the longer term there is the potential that this results in SMEs being acquired by larger firms for their skills.

Martin also noted that Slovenia will be the first country to have all roads equipped with C-ITS. C-ITS is a cheaper option than conventional road signs, which have already been deployed in more advanced countries. The countries that are just starting to develop transport management systems have the advantage of skipping obsolete technologies which have already been deployed in Western countries, and are an additional cost to replace. Martin gave the example of Romania having better broadband infrastructure than some parts of Austria, as they were able to move straight to broadband.

**D.1.2.11. Monitoring and evaluation**

The European Commission has proposed under the first Delegated Act of the ITS Directive that monitoring and evaluation will be carried out by self-assessment followed by a random inspection. For C-ITS deployment that could be enhanced by information coming from infrastructure and service providers who will inform an independent body how many vehicles are equipped, how many services are deployed, and what roads are equipped with services.

Martin noted that this process will provide a central location to collect data and ensure it is correct. This data can be used to inform OEMs and service providers what services are possible, with a central body monitoring the situation to evaluate the reliability.

Martin thought that there would be an authority for each Member State to collect the data and communicate this to the Commission and the wider stakeholder groups. This information would include the length of infrastructure, the services provided, the location of the infrastructure and services, and potentially what communication technologies are used. The OEMs know how many vehicles have C-ITS capabilities and therefore how many potential users they have.

The communication to the Commission should be in the form of a report that explains the progress made by the Member State that year. Martin suggested that all stakeholders should be obligated to report this information, as it will help develop the C-ITS deployment by raising awareness with other stakeholders.
### D.2. CASE STUDY: InterCor

<table>
<thead>
<tr>
<th>Deployment project name/title:</th>
<th>C-Roads InterCor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member State(s):</td>
<td>Netherlands, UK, Belgium, France</td>
</tr>
<tr>
<td>Project start date:</td>
<td>September 2016</td>
</tr>
<tr>
<td>Project end date:</td>
<td>August 2019</td>
</tr>
</tbody>
</table>
| Implementing body:            | Netherlands – Ministry of Infrastructure and Environment³ (Coordinator)  
                                | UK – Department for Transport⁴  
                                | France - TTP/i-Trans⁵  
                                | Belgium – Flanders/ERTICO⁶ |
| Partners:                     | Geoloc Systems⁷, I-FRET⁸, IFSTTAR⁹, mgi¹⁰, Ministry of Ecological and Solidarity Transition¹¹, Province Noord-Brabant¹², Province Utrecht¹³, SANEF¹⁴, TASS International¹⁵, TELECM Paris Tech¹⁶, Universite de Reims¹⁷, Universite de Valenciennes¹⁸ |
| Location of pilot(s):         | Netherlands – Rhine-Alpine corridor: A2, A58, A16, A15, A2 (Utrecht)  
                                | UK – North Sea-Med TEN-T corridor: Dover to Blackwell Tunnel  
                                | France - A1 motorway up to Lille and the A22 motorway between Lille and the Belgian border. An extension has been added from Lille towards Dunkirk and Calais through the A25 and A16.  
                                | Belgium – TEN-T core network: E17, R01, E19 between France and the Netherlands via Ghent and Antwerp and E34 connecting Antwerp with Eindhoven |
| Project scope - Number of vehicles: | UK - 150 |
| Project scope - Length of roads (number of RSUs): | 968 km of highway across the 4 Member States |
| Services covered:             | Netherlands – Road works warning, probe vehicle data, in-vehicle signage, green light optimisation, parking information for trucks |

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⁴ [https://www.gov.uk/government/organisations/department-for-transport](https://www.gov.uk/government/organisations/department-for-transport)  
⁷ [http://www.i-fret.org/](http://www.i-fret.org/)  
¹¹ [https://www.brabant.nl/](https://www.brabant.nl/)  
¹³ [https://www.sanef.com/](https://www.sanef.com/)  
¹⁴ [https://tass.plm.automation.siemens.com/](https://tass.plm.automation.siemens.com/)  
¹⁵ [https://www.telecom-paristech.fr/](https://www.telecom-paristech.fr/)  
D.2.1. Introduction

D.2.1.1. Background

The InterCor project links European C-ITS corridor initiatives across the Netherlands, Belgium/Flanders, UK and France, and involves 16 project partners. The aim is to create a continuous C-ITS network that can be a testbed for Day 1 (and beyond) C-ITS services deployment and development. Initially, projects within the four Member States were planned separately, but it made sense to combine efforts and facilitate effective knowledge sharing and harmonisation. It will also allow the corridor to become more commercially attractive, establishing a long-term test bed for C-ITS where interoperability can be tested. A UK project member noted that InterCor is particularly important for the UK and Belgium. They are able to learn from France and the Netherlands, who have more established corridors and more experience in C-ITS deployment.

The Traffic Division of the UK Department for Transport (DfT) is supporting the development and dissemination of innovative, C-ITS related road solutions along a Corridor that presents a challenging testbed. The UK will gradually increase deployment with a small number of vehicles (approximately 5) on the road in August 2018, rising to 150 vehicles by August 2019.

The Dutch section provides enhanced and extended test fields including strategic sections of the TEN-T Core Network, thus strengthening the efforts of the C-Roads community. Three Day 1 services (Road Works Warning, Probe Vehicle Data and In-Vehicle Signage) will be tested and deployed across the entire proposed Dutch corridor.

The French and Belgian contribution is described in the C-Roads France and C-Roads Belgium/Flanders projects separately, and both projects receive funding individually rather than through the InterCor project.

D.2.1.2. Objectives

The overarching objective for the InterCor project is to improve the safety, efficiency and convenience of mobility across Europe. Between the four Member States, cross border interoperability will be fostered and hybrid communication technologies will be tested. A common framework will be used to evaluate the many benefits of C-ITS applications to encourage investment.

D.2.2. Progress to date

In the UK in 2017, progress has been made on design, planning, developing a business case, and procurement work. The project team has secured professional services contracts to increase their technical capability and in January they will put out a tender for their main contract. This will include the supply of roadside, vehicle and back office services that are required for deployment. There is currently no infrastructure on the UK corridor at the moment.

A UK project representative noted that securing approval on the project’s business case from Highways England has been a key success. Furthermore, the UK project team has

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http://intercor-project.eu/
developed a clear system architecture and made good progress in planning their hybrid communication TESTFEST in October next year.

There are a number of TESTFESTS under InterCor with the first having taken place in July 2017, testing and harmonising ITS-G5 specifications that fed back to the C-Roads Platform. They tested all services except GLOSA with ITS-G5.

In April 2019, the French will run a Public Key Infrastructure (PKI) test, with input from the UK in designing the tests. The UK are also encouraging OEMs and suppliers to take part in this.

In October 2019, the TESTFEST will aim to create a border within the UK to test interoperability. They will test hybrid communication at a limited number of sites to allow all partners and external stakeholders with equipped vehicles to attend and test their vehicles. Here they will test both ITS-G5 and cellular and the ability to link messages between two Member State back offices.

One final TESTFEST will be conducted after the start of some of the pilots, and will validate and test all the specifications and services descriptions that have been developed.

D.2.3. Barriers and challenges

D.2.3.1. Security

A UK project member stated that a significant amount of work on security has been completed by the UK. They have been able to use internal security expertise at DfT in partnership with cyber security people from other partners such as Highways England and Transport for London (TfL). They have worked on creating a security specification and requirement for the project. The National Cyber Security Centre was also included in these discussions. They took an existing document developed by TfL for the London Underground and tailored it to the requirements of C-ITS. They have also been active in the C-Roads Security Group looking at PKIs and cyber security.

D.2.3.2. Privacy and protection of personal data

A UK representative noted that this topic is included within the ‘security’ part of their work and said that the GDPR will not add much over the existing UK data protection laws. Data protection impact assessments are currently being carried out by the UK partners, but it is too early to say what the outcomes of these will be.

Privacy requirements will be different between different services and it was highlighted by the UK representative that ‘Probe Vehicle Data’ will be the most challenging. Offering this service will require the collection of data from vehicles, and this the most ‘private’ data that is being considered at the moment. This creates a challenge in terms of user acceptance, but it is critical to the business case. Day 1.5 and Day 2 services will also require a solution to this challenge as there will be more V2V services.

D.2.3.3. Communication technologies

A UK project member noted that within InterCor, a hybrid communication approach was always agreed upon. ITS-G5 is a mature technology, so choosing a hybrid approach would allow them to test interoperability and to see if Day 1 services could be delivered by cellular at the same time as ITS-G5. There have been no identified barriers or challenges to date in the UK.

D.2.3.4. Interoperability

Functional service descriptions have proven to be a challenge, as each deployment project operates differently. Interoperability in InterCor is likely to be tested at a technical level but maybe not at a functional level.
D.2.3.5. **Compliance testing**

There have been no identified barriers or challenges to date.

D.2.3.6. **Continuity of services**

While there are a number of deployment and pilot projects in the UK, including the A2/M2 corridor and C-Mobile, a UK project member noted that there is not enough activity yet to worry about continuity of services. However, they predict that this will become a challenge in the future as deployment increases.

D.2.3.7. **Coordination**

A UK project member commented that coordination is working well within the C-Roads Platform and InterCor. However, they also noted that it is difficult to predict how Brexit will affect the UK’s involvement, but expects that the government will want to continue to work under aligned standards.

D.2.3.8. **Enabling environment**

A barrier faced in the UK was convincing road authorities to allow them to deploy C-ITS services as it is not a business-as-usual activity at this point. More work needs to be carried out around creating effective business cases and a longer-term strategy for deployment. Other stakeholders such as OEMs and telecoms companies see the benefit of doing this and are working towards it. DfT knows this technology is coming, and wants to ensure that road operators continue to be able to influence the use of the road network. Part of the business case for them will be to avoid traditional ITS deployment in favour of the newer C-ITS technologies and services.

D.2.4. **Views on proposed Delegated Regulation on C-ITS**

The interviewees were asked about their opinions and views in relation to a proposed delegated regulation on C-ITS. This section explores these views in more detail.

D.2.4.1. **Problem definition**

The UK project representative agreed with the specific root causes and objectives outlined in the problem definition.

D.2.4.2. **Security**

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<thead>
<tr>
<th>Measures considered for addressing security issues in the Delegated Act include:</th>
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<td>• Definition of operational functions and governance roles in specifications</td>
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The UK project representative commented that guidance and definition is likely the best option at the moment, as there is not a clear understanding across the C-Roads project stakeholders of what the right approach is. Therefore, it would not be helpful to mandate and commit to a specific approach until they know what will work effectively and provide a sustainable solution for the longer term. This will be tested further within the InterCor project. They also supported the definition of operational functions and governance roles in specifications and noted that there is already a good understanding of what this would look like and how it could contribute.

It was noted that what is missing from C-Roads discussions on this topic is the overall cyber-security impact assessment. Most stakeholders are currently working on creating a privacy impact assessment and a cyber security impact assessment, looking at PKIs. However, the project representative thought that overall cyber security considerations...
are missing. This would involve penetration testing to make sure that the system being connected to is secure and that when users are connected, the system is safe.

**D.2.4.3. Privacy and protection of personal data**

Measures considered for addressing privacy and data protection issues in the Delegated Act include:

- Guidance on protection of personal data and privacy policy by design and by default
- Include reference to GDPR and e-privacy in specifications
- Requirement for a Data Protection Impact Assessment (IA) in accordance with the GDPR
- Definition of principles for the practical implementation of the GDPR in the area of C-ITS in specifications
- Mandate privacy policy in specifications
- Mandate privacy IA on C-ITS data controller (art. 35 GDPR)

The UK project member agreed with the top four options. However, they highlighted that GDPR is already ‘mandated’ within law and so they have to meet these requirements anyway.

**D.2.4.4. Communication**

Measures considered for ensuring communication compatibility in the Delegated Act include:

- Technology neutrality of spectrum use
- Reference technical standards
- Embed principles of Annex II of ITS Directive (e.g. interoperability, backward compatibility)
- Mandate technical standards
- Functional description of Hybrid Communication in specifications
- Mandate mature communication technologies (with exception for pilot technologies, cf. EETS Directive)

Regarding the options presented above, the UK project representative strongly supported the option of technology neutrality, functional descriptions of Hybrid Communication and embedding principles of Annex II of the ITS Directive. They noted that mandating technical standards would be good once standards have been developed that work for everyone.

Another big challenge will be the latency in systems. This is the response time of the C-ITS service to a stimulation and is very important to safety services, which are often time critical. This is a reason why they want to test cellular, especially when they overlay the PKI, which might have an impact on latency.

**D.2.4.5. Interoperability**

Measures considered for helping to ensure interoperability in the Delegated Act include:

- Definition of technical C-ITS communication profiles in specifications
- Functional description of Day 1 services in specifications
The UK project representative noted that the challenge is to align use cases, as they are not currently harmonised across Member States. Using the example of road works warning, it was noted that the UK is the only country that has advisory speed signals, while everyone else has mandatory speed signals. The subtle differences in legislation between countries may have an impact on interoperability. These can be harmonised at a high-level but it will be challenging to harmonise the details.

**D.2.4.6. Compliance testing**

Measures considered for compliance assessment in the Delegated Act include:

- Definition of common minimum requirements for deployment of Day 1 C-ITS services in specifications
- Definition of compliance assessment process for Day 1 C-ITS services in specifications
- Requirement for any new C-ITS station to fulfil the compliance assessment criteria to be part of the C-ITS security trust model
- Ensure backward compatibility of new services and/or technologies with already deployed services
- Ensure consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.

The UK project member agreed with the top four options presented above, especially backward compatibility. They commented that it may be too early to consider the fifth option as the topic is relatively new.

**D.2.4.7. Continuity of services**

Measures considered for helping to ensure continuity of services in the Delegated Act include:

- Definition of Day 1 services in specifications
- Functional description of Day 1 services in specifications
- Reference (prioritise) deployment of Day 1 services
- Mandate combined deployment of Day 1 services

The project member was hesitant to support the mandate as it could result in committing public authorities to spending money before they have the necessary funding.

**D.2.4.8. Coordination**

Measures considered for addressing coordination issues in the Delegated Act include:

- Establishment of EU governance bodies (C-ITS governing body, C-ITS supervision body, compliance assessment bodies)
- Establishment of EU policy authorities (privacy policy authority, security policy authority, certificate policy authority)
- Establishment of EU operational bodies (trust list manager, C-ITS point of contact, EU root certification authorities)

The project member did not have a view on the options for addressing coordination issues.
D.2.4.9. Enabling environment

Measures considered for addressing enabling environment issues in the Delegated Act include:

- Policy advice through stakeholder platform
- Programme support action (PSA) under the Connecting Europe Facility (CEF) for the set-up of common EU elements
- Requirements for the exchange of best practice
- Memorandum of Understanding (MoU) in a ‘bottom-up’ approach in which stakeholders could drive activities and initiatives
- Funding for deployment projects
- Funding / coordination of research
- EU deployment coordination
- An agreement on access to selected, specified data for C-ITS services between all relevant public and private stakeholders

Mandate for standardisation organisations

The project representative thought all the options above would be useful in creating enabling environments.

D.2.4.10. Monitoring and evaluation

The project coordinator did not have a view on who should be responsible for monitoring and evaluation.

The UK project representative is involved in evaluation for InterCor and C-Roads. They noted that the biggest issue for evaluation at the pilot stage is the size of the fleet and therefore the amount of data available. Evaluation becomes easier as more vehicles and users become involved. In the UK, they have a five-part business case, but the data they are collecting from pilots are not sufficient for this process at this point.

In the longer term, operational overheads to run C-ITS services, which include monitoring and evaluation, will need to be considered.

Finally, it was highlighted that the most challenging aspect of monitoring and evaluation is collecting data from the vehicle itself. This will require agreement from the manufacturers and so with small scale deployment projects, evaluation may be per vehicle.
D.3. CASE STUDY: NordicWay

<table>
<thead>
<tr>
<th>Deployment project name/title:</th>
<th>NordicWay (Phase 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member State:</td>
<td>Denmark, Finland, Sweden, Norway</td>
</tr>
<tr>
<td>Project start date:</td>
<td>January 2015</td>
</tr>
<tr>
<td>Project end date:</td>
<td>December 2017</td>
</tr>
<tr>
<td>Implementing body:</td>
<td>Finnish Transport Agency</td>
</tr>
<tr>
<td>Partners:</td>
<td>Ministry of Transport and Communications, Swedish Transport Administration, Norwegian Public Roads Administration, Danish Road Directorate, HERE, Ericsson, Kapsch, Volvo, Scania, Finnish Transport Safety Agency TRAFI</td>
</tr>
<tr>
<td>Location of pilot(s):</td>
<td>Member States identified above</td>
</tr>
<tr>
<td>Project scope - Number of vehicles:</td>
<td>Ca. 1,850 vehicles</td>
</tr>
<tr>
<td>Project scope - Length of roads (number of RSUs):</td>
<td>Ca. 1,700 km; no RSUs</td>
</tr>
<tr>
<td>Services covered</td>
<td>Roadworks warnings, hazardous location warnings, probe data services and weather warnings.</td>
</tr>
</tbody>
</table>

D.3.1. Introduction

D.3.1.1. Background

NordicWay is a pre-deployment pilot project spanning four countries (Denmark, Finland, Sweden and Norway) and one C-ITS corridor. The project aims to test interoperable cellular communication for C-ITS services. Interoperability aims to be achieved through enabling roaming between different mobile networks and cross-border services.

The project commenced in January 2015 and was due to be completed in December 2017. Partners involved in the project include the Finnish Ministry of Transport and Communications, Swedish Transport Administration, Norwegian Public Roads Administration, Danish Road Directorate, HERE, Ericsson, Kapsch, Volvo, Scania, and the Finnish Transport Safety Agency TRAFI. The length of road affected by the project is approximately 1,700km, with 1,850 vehicles affected.

The NordicWay Interchange node has been developed and run by Ericsson. This software manages the complex multi-network and cross-border data exchange that takes place. The project is mainly focused on using cellular networks during testing of the C-ITS

20 [http://vejdirektoratet.dk/EN/roadsector/Nordicway/Pages/Default.aspx](http://vejdirektoratet.dk/EN/roadsector/Nordicway/Pages/Default.aspx)
23 [https://www.trafikverket.se/en/startpage/](https://www.trafikverket.se/en/startpage/)
25 [http://www.vejdirektoratet.dk/EN/Pages/default.aspx](http://www.vejdirektoratet.dk/EN/Pages/default.aspx)
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29 [https://www.volvocars.com/no](https://www.volvocars.com/no)
30 [https://www.scania.com/world/#/country/SE](https://www.scania.com/world/#/country/SE)
services. However, DSRC/ITS-G5 communications will be used by trailers positioned close to road works, e.g. being used as signage and communicating to vehicles approaching road works. Services that have been deployed include roadworks warnings, hazardous location warnings, probe data services and weather warnings.

D.3.1.2. Objectives
The objectives of the NordicWay project are to:

- Enable interoperable safety C-ITS communications through cellular networks;
- Facilitate automated cloud communication (using cellular networks) of data generated by vehicles and roadside infrastructure; and
- Develop a business model and scenario for deployment of cellular based C-ITS services.

D.3.2. Progress to date
Since the project started in January 2015, the NordicWay project (Phase 1) focused on setting up the C-ITS services. This focused on the development of the framework for the building of the ecosystem for the required type of cellular communication-based C-ITS. This took longer in some countries than in others. In Finland, the process took one year, whereas it took slightly less time in Sweden, and longest in Norway.

The main success to date has been the development of the communication system architecture within the project which is called the NordicWay interchange network. It is a cloud-based architecture where vehicles are connected to their associated OEM clouds and service providers (HERE in Finland) are connected to their customers via their clouds. Clouds then talk to each other using the NordicWay interchange node – which is a neutral server. The neutral server exchanges safety-related messages between the different clouds (OEM and Service providers). The project did not have to set up any roadside infrastructure to do this. Instead, the project has been able to use existing cellular networks (3G, 4G & LTE) infrastructure. All that was then required was the setting up of a system to connect the clouds of the OEMs and service providers with those of the road authorities and traffic management centres in each country. The outcome is that subsequently everyone is made aware of what is happening on the network through the interchange node and can easily provide warnings and information. The project has reported that they have achieved low latency (i.e. delay before the transmission of data), with at most a few seconds delay, but usually it is less than one second. Cross-border tests (on the Danish/Swedish and Norwegian/Swedish borders) have also been piloted. In both pilot tests, the communication system worked well with low latency. Cloud to cloud communication was the only element that they had to build and be responsible for the safety and privacy of.

The second phase of NordicWay (February 2017 to December 2020, partially overlapping with Phase 1 activities) is focused more on actual deployment with an emphasis on identifying good practices with respect to the deployment of the services. From the 1st December 2017 Finland has been informing potential participants in the deployment activity about the area that will be included (most of southern Finland). They will then be opening a call for tenders in early 2018 for the deployment of full set of Day 1 services. Each country will have their own emphasis, e.g. Sweden will have a greater emphasis on traffic signal systems. NordicWay will also look at how C-ITS can support automated driving.

D.3.3. Barriers and challenges

D.3.3.1. Security
The project lead felt that this is an issue that needs to be looked at in more detail. The NordicWay project needed to ensure that security issues did not cause further issues for road safety. The architecture design delegates many of the security requirements to
those in contact with customers (i.e. OEMs and service providers). These actors already had their own security system arrangements and contracts with the customers. In the pilots, it was a requirement for the service providers to provide a secure service to customers, according to national security requirements. The existing security was adequate and the project could certify that they met the requirements. The project team’s initial problem was the security of the interchange node and for this they had Ericsson who implemented the interchange node and who were responsible for the security arrangements here. They applied security arrangements related to open standards. No security issues were subsequently reported. However, there were minor issues related to the capacity of the first pilot server used, resulting in overloading due to the substantial number of messages.

In terms of benefits of the project – The project team believe that the architecture for cellular communication is sufficiently secure/safe, so could therefore be deployed at a much larger scale. This will be subject to testing, which will be carried out in Phase 2 of NordicWay.

**D.3.3.2. Privacy and protection of personal data**

In the NordicWay project, the main problem identified for short-distance (ITS-G5) communication is related to privacy and protection of data and arises from the necessity to identify the vehicle. Each vehicle is given a code that changes at intervals so it cannot be linked to a specific vehicle. However, the project lead identified a privacy problem in the short-range communication due to the need to send out messages every 10th of a second to locate the vehicle.

Privacy and the protection of personal data is not a problem experienced within the project’s cellular cloud architecture as this only reports data that is being exchanged between the partners and which is made available to the system. In their cellular communication system, there is no identification of the vehicle in the data exchanged and so there is privacy by design. However, privacy of the users in data exchanged with the OEMs/service providers is the responsibility of the OEM/service provider and the terms of the privacy will be outlined in their contracts. With regards to service providers, there is a privacy/data ombudsman in Finland and privacy arrangements are agreed with the official responsible for citizens’ privacy/data. It is therefore considered by the project team that privacy and personal data protection is more of an issue for ITS-G5 communication as this requires the identification of the vehicle (unlike with cellular).

**D.3.3.3. Communication technologies**

There have been limited studies that have explored the compatibility of cellular and ITS-G5 communication. NordicWay mainly focused on ensuring that their cellular communication system worked, but they did add some ITS-G5 devices into a few demonstrations. A sample of Scania trucks were equipped with both technologies and during testing, including across borders, it was found that messages were transmitted simultaneously. There are a lot of claims that cellular communications are not quick enough, but NordicWay used the pilot to show that they can be. However, the compatibility of these two technologies at a wider scale needs to be considered. In their hybrid system, cellular provides medium to long range coverage that encompasses the whole deployment system, while ITS-G5 provides short range V2V communication that is essential for many road safety-based use cases that are time-critical. This hybrid communication solution is viewed by the NordicWay team as the best solution, where all services can be efficiently provided.

**D.3.3.4. Interoperability**

The NordicWay project used the cellular network between countries and it worked well on all networks (except for some connectivity problems – see Section 1.3.6). There was an issue with applying the DATEX 2 standard, but after agreeing on the profiles it worked.
The whole focus of NordicWay was to find an interoperable solution and the project developed a solution that is easily scalable. For example, they recently successfully added an Austrian road operator (ASFINAG) (as a trial, rather than part of the pilot) to the central interchange node (communication system).

**D.3.3.5. Compliance testing**

At first the compliance assessment within the NordicWay project was focused on looking at the ITS stations and whether they comply with the relevant standards. In NordicWay they do not have any road side units, only cellular communications and the display terminals in the vehicles. They have not yet advanced to compliance assessment of the cellular communication and this needs to be considered. Compliance assessment is currently focused on ITS-G5 and the use cases using ITS-G5 communication.

**D.3.3.6. Continuity of services**

The NordicWay project experienced some problems with the cross-border tests that took place over a couple of days. In some cases, there was a delay as the vehicle reconnected to the mobile network of the new country as it crossed the border. However, in the majority of cases the reconnection was very quick, and there were no points where the vehicles were out of range. While the delay only happened in a few cases, a solution is required in the future and they are currently working on this.

The NordicWay project found that some OEMs and service provider services were only made available in selected countries (varying from country to country). For this reason, it was difficult to test interoperable services between countries. This may cause issues of continuity of services between Member States and reduce interoperability of systems if there was deployment at an EU level.

**D.3.3.7. Coordination**

During the NordicWay pilot, all partners and stakeholders agreed on requirements/roles for the duration of the project. However, Phase Two is concerned with a larger scale deployment, which may present new challenges. The coordinators acknowledge that they will need to ensure that they keep a good competitive market and do not allow a monopoly to develop.

**D.3.3.8. Enabling environment**

Part of the aim of the NordicWay pilot was to identify an ecosystem that would be suitable for C-ITS services and to generate new business. The project succeeded in this respect. The OEMs, service providers and traffic authorities are all connected with each other through the interchange network nodes. Therefore, while they are able to continue to use the information they receive from their users, they can also enrich this data with information coming through the interchange node, for other commercial uses. The architecture gives them freedom to use the data for applications other than C-ITS.

**D.3.4. Views on proposed Delegated Regulation on C-ITS**

The interviewees were asked about their opinions and views in relation to a proposed delegated regulation on C-ITS. This section explores these views in more detail.

**D.3.4.1. Problem definition**

The project coordinator confirmed that they had seen similar lists of the problems, drivers and objectives during the two phases of NordicWay project. They commented that the ‘chicken and egg’ issue has persisted, especially regarding ITS-G5.

However, it was felt that some of the specified problems are inherent to C-ITS pilots: many of the problems relate to ITS-G5 communication applications and that the use of cellular communication technology brings different problems that may not be fully captured. For example, without cellular coverage their system cannot function and so it
is an issue if coverage is missing or inadequate, as may be the case in some Member States.

For deployment of services using DSRC (dedicated short-range communications), it is also necessary to have the relevant infrastructure deployed.

### D.3.4.2. Security

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With regards to the options for security, the project co-ordinator agreed with all of them. Many have previously been set out by the security working group of the C-ITS platform. However, all have been designed for short range communication (ITS-G5), but they have less relevance to cellular cloud-to-cloud communication. Therefore, a security policy is required that includes certificate aspects for cellular cloud-related communication. It was felt that the current policy does not yet include solutions for all parts of hybrid communication.

### D.3.4.3. Privacy and protection of personal data

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With regards to the options for privacy and protection of personal details, privacy by design is what the NordicWay project is aiming for. In Finland, the ‘My Data’ principles are in force, which gives users the right to say where their personal data is used.
D.3.4.4. Communication

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</tbody>
</table>

In terms of the options presented in relation to communication, the project coordinator considers it to be a good list. Technology neutrality is extremely important and an issue that is highlighted in the NordicWay project. Technologies are constantly developing and therefore there needs to be neutrality in the spectrum use to be able to react to technological development. It was considered that technical standards could be mandated, but that existing technical standards are not enough and a communication profile is required to ensure all stakeholders apply the standards in the same way (given as an option in relation to interoperability). It was pointed out that there is a risk that technical standards can be interpreted differently. Through experience, the NordicWay project demonstrated that although the same standards are followed, they can be applied in several ways. ITS Standards are also evolving (i.e. DATEX), so the regulatory framework needs to be wary of this.

The project coordinator does not believe that mature communication technologies should be mandated as technologies are constantly evolving. If a solution is agreed upon by all relevant stakeholders, then a mandate is suitable. But whilst there is disagreement within the industry and between Member States, it should not be mandated.

Finally, it was stated that ensuring compatibility is a challenge - it is not realistic or always useful to demand backwards compatibility.

D.3.4.5. Interoperability

<table>
<thead>
<tr>
<th>Measures considered for helping to ensure interoperability in the Delegated Act</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition of technical C-ITS communication profiles in specifications</td>
<td></td>
</tr>
<tr>
<td>Functional description of Day 1 services in specifications</td>
<td></td>
</tr>
</tbody>
</table>

The project coordinator agreed with the options presented for interoperability. However, they pointed out that it is not just the short-range, but also medium/long-range cellular option that needs to be considered.
D.3.4.6.  **Compliance testing**

<table>
<thead>
<tr>
<th>Measures considered for compliance assessment in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Definition of common minimum requirements for deployment of Day 1 C-ITS services in specifications</td>
</tr>
<tr>
<td>• Definition of compliance assessment process for Day 1 C-ITS services in specifications</td>
</tr>
<tr>
<td>• Requirement for any new C-ITS station to fulfil the compliance assessment criteria to be part of the C-ITS security trust model</td>
</tr>
<tr>
<td>• Ensure backward compatibility of new services and/or technologies with already deployed services</td>
</tr>
<tr>
<td>• Ensure consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.</td>
</tr>
</tbody>
</table>

The project coordinator largely agreed with the compliance testing options presented. It was suggested that embedding backward compatibility may potentially cause problems – the value in it is recognised but it could become a burden if the technology quickly becomes outdated.

D.3.4.7.  **Continuity of services**

<table>
<thead>
<tr>
<th>Measures considered for helping to ensure continuity of services in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Definition of Day 1 services in specifications</td>
</tr>
<tr>
<td>• Functional description of Day 1 services in specifications</td>
</tr>
<tr>
<td>• Reference (prioritise) deployment of Day 1 services</td>
</tr>
<tr>
<td>• Mandate combined deployment of Day 1 services</td>
</tr>
</tbody>
</table>

The project coordinator did not consider the options relating to continuity of services to adequately address the main issue, which they consider to be the willingness to share data.

Through experience in the NordicWay project, a service provider stated that there would be an additional cost to provide data/services in certain countries. This leaves the question of who would be responsible and willing to carry this cost and pay to ensure that a service could be carried out. Such issues require discussion with and engagement of industry stakeholders, acknowledging that there are different standards and services offered in each country.

For NordicWay, the countries have similar mobile network coverage and pricing policies for mobile data. However, when considering EU-wide deployment, there would be issues relating to differing mobile data pricing practices and cellular coverage. Individuals in the Nordic countries tend to buy communications in packages that have no limits on data use (unlimited data use, affordable); data packages in the region are very cheap. However, this could be an issue for other Member States where this is not the norm, in which there might be less bandwidth for cellular data and pricing issues.
D.3.4.8. Coordination

Measures considered for addressing coordination issues in the Delegated Act include:

- Establishment of EU governance bodies (C-ITS governing body, C-ITS supervision body, compliance assessment bodies)
- Establishment of EU policy authorities (privacy policy authority, security policy authority, certificate policy authority)
- Establishment of EU operational bodies (trust list manager, C-ITS point of contact, EU root certification authorities)

As stated previously, the project coordinator does not think that backwards compatibility of technology is suitable and that coordination is required to ensure technology remains compatible. It is acknowledged that it will be a challenge to engage industry stakeholders in this level of coordination as they are typically working at a global level and are unlikely to be willing to do what EU Member States want them to do. The project coordinator stated that a solution should therefore be sought where Member States and key industry stakeholders reach an agreement. Furthermore, the project coordinator noted that it is the industry as global players who will eventually determine what technologies will be used at the EU level. Here there is also the challenge of industry players needing to agree amongst themselves on technology choices.

It was agreed that the establishment of the suggested EU bodies is required. However, it was acknowledged that it would be difficult for a governance body to manage all of the relevant stakeholders. Supervision/compliance assessment bodies are also required, which should be approved by all relevant stakeholders. Preferably existing supervision and compliance assessment bodies in the EU and the Member States could be used to fulfil such functions.

D.3.4.9. Enabling environment

Measures considered for addressing enabling environment issues in the Delegated Act include:

- Policy advice through stakeholder platform
- Programme support action (PSA) under the Connecting Europe Facility (CEF) for the set-up of common EU elements
- Requirements for the exchange of best practice
- Memorandum of Understanding (MoU) in a ‘bottom-up’ approach in which stakeholders could drive activities and initiatives
- Funding for deployment projects
- Funding / coordination of research
- EU deployment coordination
- An agreement on access to selected, specified data for C-ITS services between all relevant public and private stakeholders
- Mandate for standardisation organisations

With regards to the option concerning EU deployment coordination, it was acknowledged that it is possible to coordinate what is in the hands of the Member States, but it is difficult to coordinate commercial deployment. It was suggested that coordination involving financial incentives may help the situation.

Connected vehicles provide large volumes of data which can potentially have a range of applications and uses aside from C-ITS applications. The project coordinators believe that the deployment of C-ITS is more likely if stakeholders can conduct business (e.g. with the other data that is being generated) for purposes other than just safety-related
C-ITS services. The cloud-based system enriches the data by combining multiple inputs, making the data more valuable.

D.3.4.10. Other discussion points

It was suggested that to make a Delegated Act there needs to be a specific level of maturity and so the Commission has utilised the C-ITS Platform Phase 1 and 2 wisely within the support study to the IA to see which service aspects are at a suitable level of maturity.

In terms of potential impacts for SMEs, the NordicWay project has demonstrated that there are potentially positive impacts. One SME from Tampere was involved in the Finnish pilot, maintaining the Finnish transport cloud to provide the connection with the traffic management centres and Finnish Transport Agency information systems. They have found their involvement to be beneficial for them, as they have had an opportunity to learn about C-ITS and gain experience in this area. It is likely to have a permanent impact on them in terms of their expertise. Further deployment may influence SMEs in similar areas of the system.

According to the NordicWay project coordinator, authorities are likely to be typically looking for value of money in the activities they are involved in. Due to declining public sector budgets, they will have to carefully consider what they invest in. If C-ITS has a good business case, then they will likely invest – and it potentially is a good investment based on the results to date. Each of the Member States will have to be convinced and ensure compatibility with their own transport policy/objectives etc.

The project coordinator noted that European projects such as EasyWay and EU EIP have also shown that Member States, while agreeing on European corridor-level priorities, eventually invest in solving local transport problems. Hence, C-ITS deployments may also result in a separated islands of service availability unless corridor-level and wide-area deployments are encouraged, for instance via financial incentives (CEF funding etc.)

D.3.4.11. Monitoring and evaluation

Monitoring is a routine part of what the NordicWay project is currently doing and it should be required as part of the C-ITS Delegated Act.

A key issue to be considered in relation to monitoring and evaluation is what is happening in the private sector and whether it can be monitored effectively. It is possible to evaluate the end product, but this will require some investment in the evaluation process.
## D.4. CASE STUDY: C-The Difference

<table>
<thead>
<tr>
<th>Deployment project name/title:</th>
<th>C-The Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member State:</td>
<td>France, Netherlands</td>
</tr>
<tr>
<td>Project start date:</td>
<td>October 2016</td>
</tr>
<tr>
<td>Project end date:</td>
<td>September 2018</td>
</tr>
<tr>
<td>Implementing body:</td>
<td>Consortium led by Belrvaque Sprl</td>
</tr>
<tr>
<td>Partners:</td>
<td>Bordeaux Metropole[^31^-^31], Gemeente Helmond[^32^-^32], Dynniq[^33^-^33], Geoloc Systems[^34^-^34], MAP Traffic Management[^35^-^35], TNO[^36^-^36], Cerema[^37^-^37], IFSTTAR[^38^-^38]</td>
</tr>
<tr>
<td>Location of pilot(s):</td>
<td>Bordeaux, France and Helmond, Netherlands</td>
</tr>
</tbody>
</table>
| Project scope - Number of vehicles: | In Bordeaux: 32 passenger cars and 9 commercial vehicles equipped with ITS-G5 on board units. Over 900 personal and 100 commercial mobile app users.  
In Helmond: 103 commercial vehicles equipped with ITS-G5 on board units (Trucks and emergency vehicles). |
| Project scope - Length of roads (number of RSUs): | 373 intersections in Bordeaux and 1527 traffic lights (36 RSUs)  
28 intersections in Helmond and 308 traffic lights (28 RSUs) |
| Services covered:             | Bordeaux | Helmond |
| Emergency vehicle approaching | ITS-G5 | ITS-G5 |
| Road hazard warning           | ITS-G5 & 3G/4G |
| Road works warning            | ITS-G5 & 3G/4G |
| In-vehicle signage            | 3G/4G |
| Park & ride information       | 3G/4G |
| Probe vehicle data            | 3G/4G |
| Signal violation / Intersection Safety | ITS-G5 & 3G/4G |
| Traffic signal priority for designated vehicles | ITS-G5 |
| Green Light Optimal Speed Advisory | ITS-G5 & 3G/4G |
| Tram GLOSA                    | 3G/4G |

[^31]: http://www.bordeaux-metropole.fr/  
[^32]: https://www.helmond.nl/inwoner  
[^33]: http://dynniq.com/  
[^34]: http://www.geolocsystems.com/  
[^35]: http://www.maptm.nl/  
[^36]: https://www.tno.nl/en/  
[^37]: http://www.sud-ouest.cerema.fr/  
[^38]: http://www.ifsttar.fr/accueil/
D.4.1. Introduction

D.4.1.1. Background

The partners involved in the C-The Difference project have been working on bringing C-ITS services to market for the last 10 years. They represent both demand and supply sides of the industry and have already invested significantly in the development and deployment of C-ITS, which they believe has the capacity to provide an efficient and cost-effective solution to urban mobility problems.

The research that has already been carried out provides a strong scientific background for an impact assessment of the deployment of C-ITS in the two partner cities. However, it will be important to translate the results of the impact assessment into indicators that can be used by policy makers and transport planners elsewhere. The project aims to support cities in making informed decisions on where to invest in order for C-ITS to meet the objectives of local policy.

The two cities involved, Helmond and Bordeaux, were both been involved in the COMPASS4D project and so they have existing local systems developed for running the projects. The two cities are among the most advanced cities in Europe for the deployment of C-ITS and through the City Twinning Programme, the project will share knowledge with other cities to encourage replication of the successes. As part of this, the project team is carrying out a workshop in Helmond and Bordeaux for other city delegates to attend.

The C-The Difference partners believe that successful implementation of C-ITS services rely on five golden rules; interoperability, sustainability, scalability, replicability and reliability.

D.4.1.2. Objectives

The C-The Difference project has three main objectives:

- To deliver an impact assessment for the C-ITS services package, based on up to 18 months of operation.
- To cross the bridge between state of the art C-ITS implementation in an urban environment and large-scale deployment and operations, bringing together professionals responsible for urban transport planning and operations, as well as policy and decision makers.
- Encourage other cities to invest in mature and proven C-ITS solutions, by fostering knowledge sharing and C-ITS pilot best practices exchange, using the City Twinning Programme.

D.4.2. Progress to date

As of November 2017, the project was halfway complete. One of the early achievements of the project was the development of the evaluation methodology. This had to be harmonised so that it could be used for both cities to allow the results to be comparable. The implementation work has now been finalised with all the C-ITS services in operation, which was another significant achievement within the first year of the project. The services were selected to support the project’s policy of demonstrating that C-ITS can be an effective solution in the transport sector. In Bordeaux, ten services have been implemented, while five have been introduced in Helmond (see summary table).

Part of the implementation process was to upscale C-ITS deployment in both cities. In Helmond, the upscaling focused on increasing the number of participating trucks (from 10 to over 100) and to upgrade the roadside equipment in line with the evolution of the technology. In Bordeaux, the upscaling targeted individual users using combined ITS-G5 and cellular communication rather than just ITS-G5. Some of the services have been

39 http://c-thedifference.eu/
developed to be used on a smartphone app, which is available free of charge on the google store. This removes the requirement for users to equip their car with an aftermarket device; instead they only have to download the app.

The piloting activities began in April/May, which gives the project team around 15 months to collect data for the impact assessment.

**D.4.3. Barriers and challenges**

**D.4.3.1. Security**

Security has not been an issue in the project. The project lead commented that working in the closed environment of a city has helped to reduce the likelihood of security threats. However, wider scale deployment in the future would lead to more security threats as the technology became more commonly used.

**D.4.3.2. Privacy and protection of personal data**

In Bordeaux, the project team manages a large community of users, which presents challenges to safely manage privacy and the protection of personal data. They have a specific IT architecture to manage the database and they follow specific processes set by the French Commission in order to comply with the legal obligations in France. The national rules on privacy focus on the anonymisation and the control of access to data. The smartphone app does not collect personal data from users. The two organisations that are responsible for carrying out the impact assessment have access to all data within the project, but they have received consent from the national authority on privacy (CNIL).

In Helmond, the target group is truck drivers and the fleet operators are volunteers. The drivers are accustomed to systems that track them while driving and which record their driving behaviour, so this has not proved to be an issue. Additionally, the project does not acquire data that is person-specific, as it tracks trucks not people. There has been more sensitivity from the road authority about the collection of data for services relating to pedestrians and cyclists. The project team expects that with larger scale deployment encompassing more services and users, they would have to review their approach to privacy and the protection of data.

**D.4.3.3. Communication technologies**

Hybrid communication is implemented in Bordeaux. ITS-G5 is used for time-critical services, which is a legacy of the technology deployed during the Compass4D and SCOOP@F projects. The additional services have been deployed using cellular. For safety applications, when the service is time-critical, only ITS-G5 is used (as is the project team has found this to be more reliable). For information services, the two technologies have been deployed to be complementary, with the project team comparing and observing the coexistence of the two technologies. So far there has been no inconsistency in the information delivered between the two technologies in services that use them in parallel. Due to cost issues, some services have been implemented only using cellular to allow for a larger coverage of roads.

In Helmond, they have only used ITS-G5 technology. However, in 2018 it will become a hybrid C-ITS environment as they will deploy roadside units that support ITS-G5 and cellular technology. From a technical point of view, there is no distinction between road users who are linked to traffic controllers by either technology although there are availability issues depending on the use case (e.g. safety applications).

**D.4.3.4. Interoperability**

Interoperability was viewed as important by the project team. Within the project, they are gaining experience in implementing standards as well as developing them. Interoperability can be ensured through the consistent implementation of standards by different stakeholders. The issue is that standards are just pieces of text that can easily
be interpreted differently and so it is necessary to have a common understanding of how to apply the standard in the physical implementation of a service. The project team are coordinating with the C-Roads platform, who have experience in this process, which should address this issue.

**D.4.3.5. Compliance testing**

No issues or challenges were identified by the project representatives.

**D.4.3.6. Continuity of services**

As Bordeaux is the pilot site for deployment projects in both the C-The Difference and C-Roads France projects, there has been cooperation between the two projects to address continuity.

In Helmond, they are introducing a nationwide cloud-based platform to collect and share data between infrastructure, vehicles and people, called Talking Traffic. So far there have been no issues as long as the ITS-G5 communication technology works, but there may be issues when they move to hybrid communication. When the system moves onto the Talking Traffic platform, RSUs, OBUs and traffic controller applications will operate under a new standard and may interact with services from other projects such as InterCor. This change may create issues, but it is important for Helmond, which is at the forefront of C-ITS deployment in Netherlands, to identify and address any issues effectively and quickly.

**D.4.3.7. Coordination**

In Bordeaux, the project team is concerned with the traffic on ring roads. As ring roads are not clearly defined as being either urban or interurban, there needs to be strong coordination between operators and authorities. Consideration needs to be given to how to address the needs of services on ring roads as they experience heavy traffic and so C-ITS services have a large potential positive impact.

**D.4.4. Enabling environment**

The most challenging issue identified by the project team was interact and engage with more cities, as part of their Twinning Programme. They have made progress but have so far involved less than 1 percent of total number of cities in the EU; engaging the remaining cities will require a long-term effort.

There have been a number of challenges:

- It has been difficult to convince large cities to adopt the results of these pilot studies and to invest in C-ITS in order to deliver the benefits that the services can bring.

- While the technology does not present a major barrier, the challenge is how to organise the process of deployment. This includes market regulation, ensuring fair competition, and developing harmonised standards and an open ecosystem.

- Cities that deploy C-ITS tend to create island solutions that are not widely applicable. While it is positive that in the Netherlands they have started to create an open ecosystem, as noted above. It is challenging to bring together regulatory authorities and industry to develop open solutions.

- The political context at the national and regional levels can also be an issue. For example, there is a variation in the budget that cities will allocate to C-ITS. It is therefore important to demonstrate that there are immediate benefits to investing in C-ITS.

- There is often a complex consortium involved in deployment including transport operators and partners that manage transport systems and traffic.
D.4.4.1. Others

The project team found that having a larger fleet involved required them to accommodate a variety of routes and this increased the complexity of the project. Finding a solution was an important exercise and so they see larger deployment as a good exercise to learn about multiple users in the system.

D.4.5. Views on proposed Delegated Regulation on C-ITS

D.4.5.1. Problem definition

No views were provided on the problem definition due to a lack of time.

D.4.5.2. Security

<table>
<thead>
<tr>
<th>Measures considered for addressing security issues in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Guidance on Security and Certificate policy</td>
</tr>
<tr>
<td>• Definition of Security and Certificate policy in specifications</td>
</tr>
<tr>
<td>• Mandate Security and Certificate policy</td>
</tr>
<tr>
<td>• Definition of operational functions and governance roles in specifications</td>
</tr>
</tbody>
</table>

The project team did not identify any specific requirements in relation to security compared to other pilots in the trans-EU corridors. They did note that security is an important issue in the urban environment as you have more people than on a corridor, but they had no specific message on this issue.

D.4.5.3. Privacy and protection of personal data

<table>
<thead>
<tr>
<th>Measures considered for addressing privacy and data protection issues in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Guidance on protection of personal data and privacy policy by design and by default</td>
</tr>
<tr>
<td>• Include reference to GDPR and e-privacy in specifications</td>
</tr>
<tr>
<td>• Requirement for a Data Protection Impact Assessment (IA) in accordance with the GDPR</td>
</tr>
<tr>
<td>• Definition of principles for the practical implementation of the GDPR in C-ITS in specifications</td>
</tr>
<tr>
<td>• Mandate privacy policy in specifications</td>
</tr>
<tr>
<td>• Mandate privacy IA on C-ITS data controller (art. 35 GDPR)</td>
</tr>
</tbody>
</table>

The project lead stated that the current practices are adequate and that there are no differences between the current regulation and practices. They did not do anything different compared to projects that have already deployed services.
D.4.5.4. Communication

Measures considered for ensuring communication compatibility in the Delegated Act include:

- Technology neutrality of spectrum use
- Reference technical standards
- Embed principles of Annex II of ITS Directive (e.g. interoperability, backward compatibility)
- Mandate technical standards
- Functional description of Hybrid Communication in specifications
- Mandate mature communication technologies (with exception for pilot technologies, cf. EETS Directive)

Within the project and elsewhere there is a debate on which technology – ITS-G5 or cellular – is better. The project lead supported both technologies but recognised the differences in cost and the dependence on cellular networks for emergencies. The project team has also noticed inconsistency between the EU automotive and telecoms industries in their views on communications technology. This creates uncertainty for road authorities as to what their future actions should be. The project team felt that it is important that the Commission recognises this issue as initiating discussions on which technology will be best in the future will only delay any decision from road operators and authorities. It was the project lead’s view that C-ITS should be deployed using the technology that is currently available, while at the same time developing an architecture that can include future technologies and allow the system to be backward compatible. Backward compatibility is an important consideration when deciding on the lifetime of the investment and to ensure it, the service layer should be independent from the communications technology.

The project lead highlighted the importance of a clear differentiation between the communications infrastructure and the services being deployed. It must be possible to deploy services independent of the communication technology used. The priority is the availability and quality of services; services need to be able to be run in either a hybrid, cellular or ITS-G5 environment.

D.4.5.5. Interoperability

Measures considered for helping to ensure interoperability in the Delegated Act include:

- Definition of technical C-ITS communication profiles in specifications
- Functional description of Day 1 services in specifications

Interoperability tests must be part of compliance assessment. Cities do not always understand the need for interoperability as they largely deal with local traffic and not cross-border traffic. Therefore, at the local level, this needs to be addressed in a different way to that of the trans-EU corridors (i.e. in the other C-Roads projects). Cost will be a crucial factor; if the same standards are used, costs will be reduced through economies of scale making deployment more accessible for smaller cities.
D.4.5.6. Compliance testing

Measures considered for compliance assessment in the Delegated Act include:

- Definition of common minimum requirements for deployment of Day 1 C-ITS services in specifications
- Definition of compliance assessment process for Day 1 C-ITS services in specifications
- Requirement for any new C-ITS station to fulfil the compliance assessment criteria to be part of the C-ITS security trust model
- Ensure backward compatibility of new services and/or technologies with already deployed services
- Ensure consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.

No views were expressed by the project representatives.

D.4.5.7. Continuity of services

Measures considered for helping to ensure continuity of services in the Delegated Act include:

- Definition of Day 1 services in specifications
- Functional description of Day 1 services in specifications
- Reference (prioritise) deployment of Day 1 services
- Mandate combined deployment of Day 1 services

No views were expressed by the project representatives.

D.4.5.8. Coordination

Measures considered for addressing coordination issues in the Delegated Act include:

- Establishment of EU governance bodies (C-ITS governing body, C-ITS supervision body, compliance assessment bodies)
- Establishment of EU policy authorities (privacy policy authority, security policy authority, certificate policy authority)
- Establishment of EU operational bodies (trust list manager, C-ITS point of contact, EU root certification authorities)

The project team was pleased with the work of C-Roads in coordinating C-ITS deployment across Member States. While this is a huge challenge, it was highlighted that bringing together thousands of cities presents an even larger challenge and C-Roads needs to take account of the diversity of cities and regions. They also noted that there needs to be better integration between the interurban and the urban environment, in particular on ring roads, which represent this boundary. While the priority of C-Roads is to address interurban roads, the project team felt that there is a challenge to also address urban nodes and to gain experience from deployment on ring roads to better understand how C-ITS services can best fulfil the needs of these roads.
**D.4.5.9. Enabling environment**

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</tr>
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<td>• Mandate for standardisation organisations</td>
</tr>
</tbody>
</table>

The issues raised in Section 1.3.8, regarding the enabling environment of the project are also relevant to enabling environments of deployment across Europe. The points have been repeated below:

- The need to convince the large cities to adopt the results from these pilot studies and invest in C-ITS.
- How to organise the process of deployment, as this requires market regulation, ensuring fair competition, and the development of harmonised standards and an open ecosystem.
- The need to bring together regulatory authorities and industry to develop open solutions.
- Overcoming the differences in the political context at national and regional levels, particularly in relation to the budgets allocated to C-ITS.
- The challenges of the complex consortium involved in C-ITS deployment.

**D.4.5.10. Other discussion points**

A point made by the project lead concerned how any proposed Delegated Act would be translated at a local level by cities. There may be the need to gain more knowledge at the local level, so cities should be engaged as early as possible and play a role in C-ITS deployment. There needs to be a better understanding of what a Delegated Act would mean for cities.

**D.4.5.11. Monitoring and evaluation**

There is a need to align and harmonise the monitoring and evaluation methodology. In the C-The Difference project, they took the methodology from Compass 4D and developed a harmonised methodology through cooperation with both partners. There needs to be even more piloting activities, but to share knowledge the same evaluation methodology is required to compare and aggregate results.
## D.5. CASE STUDY: C-Roads Belgium/Flanders

<table>
<thead>
<tr>
<th>Deployment project name/title:</th>
<th>C-Roads Belgium/Flanders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member State(s):</td>
<td>Belgium</td>
</tr>
<tr>
<td>Project start date:</td>
<td>February 2016</td>
</tr>
<tr>
<td>Project End Date:</td>
<td>December 2020</td>
</tr>
<tr>
<td>Implementing body:</td>
<td>Consortium</td>
</tr>
<tr>
<td>Partners:</td>
<td>Flemish Department of Mobility(^{40}), HERE(^{41}), ITS.be(^{42}), Tractebel Engineering(^{43})</td>
</tr>
</tbody>
</table>
| C-ITS services that have been/are being piloted: | - Temporarily slippery road  
  - Reduced visibility  
  - Exceptional weather conditions  
  - (Fixed/stationary) Road works  
  - Slow and stationary vehicle  
  - (Unprotected) Accident area  
  - Obstacle on the road  
  - Traffic jam ahead warning  
  - Current speed limit: static from HERE map and dynamic from TMC  
  - Shockwave Damping based on Wide Moving Jam |
| Location of pilot(s):         | All core motorways in Flanders: E17/E19, E34 and E40 (TEN-T). Emphasis given to Antwerp area (including connections with the Netherlands): R001, E19, E34 and E313 |
| Project scope - Number of vehicles: | 1,000 vehicles |
| Project scope - Length of roads: | ~2000km |
| Project Scope - Number of users: | 1,000 users |

### D.5.1. Introduction

#### D.5.1.1. Background

The C-Roads Belgium/Flanders pilot is running in parallel with projects InterCor\(^{44}\) and Citrus\(^{45}\), to explore and validate specific approaches for larger scale C-ITS roll out. The present pilot enables the provision of certain Day 1 and Day 1.5 services by building on a cloud based ‘virtual infrastructure’ and existing cellular (3G-4G/LTE) communication technology. It aims to establish fast and trusted messaging between users and the public Traffic Centre Flanders. Use Cases will be tested across all motorways of Flanders with a focus on the E313 Motorway and the Antwerp area, which are very congested.

\(^{40}\) [http://www.watlab.be/](http://www.watlab.be/)
\(^{42}\) [http://its.be/](http://its.be/)
\(^{44}\) [http://intercor-project.eu/](http://intercor-project.eu/)
\(^{45}\) [https://www.citrus-project.eu/](https://www.citrus-project.eu/)
D.5.1.2. Objectives

The C-Roads Belgium project has the main objective of exploring and validating specific approaches for larger scale C-ITS roll out using cloud based infrastructure and cellular communication technology. This will allow a two-way connection between road users and the Traffic Management Centre (TMC).

Additionally, the Traffic Centre is to be upgraded with a web based TMC Incident Dashboard to accommodate and process incoming user- and vehicle generated messages.

D.5.2. Progress to date

HERE, who are one of the main partners, are adapting the virtual infrastructure tested in Nordic Way and developing the services and applications that will be put into the test vehicles. Test drivers will be selected in the second half of 2018 and testing will be carried out in 2019/2020.

A project lead highlighted that a key success has been the development of the use cases document, which clearly describes the services that will be deployed.

D.5.3. Barriers and challenges

D.5.3.1. Security

The functional architecture building on cellular communication already incorporates elements and layers ensuring a significant level of data security. However, the exact boundaries of the C-ITS trust domain may need to be agreed depending on the specific requirements of a certain service. Defining such boundaries is taken up by the C-Roads platform Working Group 2 or an operating sub-Task Force, as it goes beyond the scope of the pilot project. The project team foresee data quality and security as key to the establishment of trust and broader roll-out.

D.5.3.2. Privacy and protection of personal data

The services which are developed within C-ROADS Belgium/Flanders are in principle GDPR compliant. However, for evaluation purposes the team expect a temporary need for additional data related to the pilot users that would qualify as personal data. Therefore, the project team is analysing the full impact of GDPR and how it will affect their ability to collect data for evaluation purposes. Partners HERE and Tractebel are currently examining how all requirements can be met at reasonable cost and within the given timeframe.

As the validation and evaluation elements of the pilot incorporate a research perspective, it needs to be clarified if and how exactly required data can be accessed and stored, and a platform-wide agreed clarification would be preferred.

D.5.3.3. Communication technologies

The project builds on available 3G/4G communication networks and technology for which the functional architecture incorporates elements and layers that at least partly tackle issues related to security, privacy and authentication.

C-Roads Belgium/Flanders also wish to refer to the Concorda project running in parallel, that aims to assess the performance of hybrid communication systems.

D.5.3.4. Interoperability

The project team view interoperable deployment and continuity of service as key requirements for effective uptake and market penetration of C-ITS services. For data exchange between the cloud and back-office(s), the increasingly standardised Datex is being used. The project lead highlighted that service interoperability and continuity...
should not be impacted by the communication technology used, as this would lower benefits and have a negative effect on users’ trust and willingness to use the service.

D.5.3.5. **Compliance testing**

There has been limited discussion within the project consortium regarding compliance assessment, which needs to build on specifications established and interoperability defined. It is assumed such work can start once the ‘hybrid’ specifications (under the C-Roads platform) are available and agreement is reached on definitions and the boundaries of the C-ITS Trust domain.

D.5.3.6. **Continuity of services**

The project lead noted that as C-Roads Belgium relies on 3G/4G architecture, it is currently focussing on the in-vehicle app and the virtual infrastructure required.

D.5.3.7. **Coordination**

No Identified barriers or challenges to date.

D.5.3.8. **Enabling environment**

No Identified barriers or challenges to date.

D.5.4. **Views on proposed Delegated Regulation on C-ITS**

D.5.4.1. **Problem definition**

The project lead commented that one of the main barriers is a lack of good business models and poor coordination between the private and public sector.

D.5.4.2. **Security**

<table>
<thead>
<tr>
<th>Measures considered for addressing security issues in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Guidance on Security and Certificate policy</td>
</tr>
<tr>
<td>• Definition of Security and Certificate policy in specifications</td>
</tr>
<tr>
<td>• Mandate Security and Certificate policy</td>
</tr>
<tr>
<td>• Definition of operational functions and governance roles in specifications</td>
</tr>
</tbody>
</table>

The project lead considered guidance as sufficient for cellular communication because security is largely the responsibility of the service provider. It was noted that the boundaries of the C-ITS Trust domain needs to be clarified. The project lead proposed that a Public Key Infrastructure (PKI) based implementation is necessary in the following cases:

- When the connection between two or more IT Sub-Stations (ITS-S) are changing dynamically.
- When ITS-S is transmitting C-ITS information or service directly to another ITS-S.
- When the information an ITS-Station is transmitting is trustworthy, such as trusted and accurate sensor data or server aggregated data.

Whereas the PKI based implementation may apply if/when:

- ITS-S is communicating server hosted data to predefined end-points such as mobile applications.
- The ITS-S or server is transmitting non-aggregated 'raw data' such as data from weather or road sensors or (informational) user generated data.
- Communication between server platforms is aggregating the data.

Ref: Ricardo/ED10644/3
The project consortium proposes the following clarifications with regard to the role of Mobile Device-based C-ITS applications (Personal ITS-S):

- Mobile device-based C-ITS applications are considered as Personal ITS-S.
- C-ITS applications on mobile devices should incorporate security and privacy related functionalities as specified in C-ITS Security and Certificate policies.
- Provisions for security and privacy on mobile devices may be based on alternative technologies such as SSL and https - commonly used Internet domain technologies to ensure authenticity of the origin of the data and for enabling consumer access to the service.
- Mobile device-based C-ITS applications send or receive C-ITS information to/from a single source - an application specific server. Therefore C-ITS applications on mobile devices would not be bound to generic compliance assessment or certification.

**D.5.4.3. Privacy and protection of personal data**

<table>
<thead>
<tr>
<th>Measures considered for addressing privacy and data protection issues in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Guidance on protection of personal data and privacy policy by design and by default</td>
</tr>
<tr>
<td>• Include reference to GDPR and e-privacy in specifications</td>
</tr>
<tr>
<td>• Requirement for a Data Protection Impact Assessment (IA) in accordance with the GDPR</td>
</tr>
<tr>
<td>• Definition of principles for the practical implementation of the GDPR in C-ITS in specifications</td>
</tr>
<tr>
<td>• Mandate privacy policy in specifications</td>
</tr>
<tr>
<td>• Mandate privacy IA on C-ITS data controller (art. 35 GDPR)</td>
</tr>
</tbody>
</table>

In the situation of general deployment, the project lead supported the requirement for a Data Protection IA and a definition of principles for the practical implementation of the GDPR. However, they are not in support of mandating a privacy policy. The project lead noted that a platform-wide agreed clarification is needed on how exactly required data can be accessed and stored under GDPR rules.
D.5.4.4. Communication

Measures considered for ensuring communication compatibility in the Delegated Act include:

- Technology neutrality of spectrum use
- Reference technical standards
- Embed principles of Annex II of ITS Directive (e.g. interoperability, backward compatibility)
- Mandate technical standards
- Functional description of Hybrid Communication in specifications
- Mandate mature communication technologies (with exception for pilot technologies, cf. EETS Directive)

The project lead would like to make sure that implementation guidance is provided for different communication technology approaches.

D.5.4.5. Interoperability

Measures considered for helping to ensure interoperability in the Delegated Act include:

- Definition of technical C-ITS communication profiles in specifications
- Functional description of day 1 services in specifications

No views were expressed on interoperability.

D.5.4.6. Compliance testing

Measures considered for compliance assessment in the Delegated Act include:

- Definition of common minimum requirements for deployment of Day 1 C-ITS services in specifications
- Definition of compliance assessment process for Day 1 C-ITS services in specifications
- Requirement for any new C-ITS station to fulfil the compliance assessment criteria to be part of the C-ITS security trust model
- Ensure backward compatibility of new services and/or technologies with already deployed services
- Ensure consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.

The project lead was in favour of including a definition of minimum requirements for deployment, and ensuring backward compatibility of the service (not technologies) in the delegated act.
D.5.4.7. **Continuity of services**

Measures considered for helping to ensure continuity of services in the Delegated Act include:

- Definition of day 1 services in specifications
- Functional description of day 1 services in specifications
- Reference (prioritise) deployment of Day 1 services
- Mandate combined deployment of Day 1 services

The project lead supported the definition of Day 1 services in specifications, whereas reference deployment of selective Day 1 services should be examined for fostering implementation and therefore establishing a critical mass.

D.5.4.8. **Coordination**

Measures considered for addressing coordination issues in the Delegated Act include:

- Establishment of EU governance bodies (C-ITS governing body, C-ITS supervision body, compliance assessment bodies)
- Establishment of EU policy authorities (privacy policy authority, security policy authority, certificate policy authority)
- Establishment of EU operational bodies (trust list manager, C-ITS point of contact, EU root certification authorities)

The project lead confirmed that communication between the public and private sector is very important. They noted that it is also important to have rules for the public sector that describes what data they have to provide to the private sector. The project lead believes that this is already defined in several Delegated Acts. Similarly, it is also important to have rules that define how the private sector have to respond to mandates.

D.5.4.9. **Enabling environment**

Measures considered for addressing enabling environment issues in the Delegated Act include:

- Policy advice through stakeholder platform
- Programme support action (PSA) under the Connecting Europe Facility (CEF) for the set-up of common EU elements
- Requirements for the exchange of best practice
- Memorandum of Understanding (MoU) in a ‘bottom-up’ approach in which stakeholders could drive activities and initiatives
- Funding for deployment projects
- Funding / coordination of research
- EU deployment coordination
- An agreement on access to selected, specified data for C-ITS services between all relevant public and private stakeholders
- Mandate for standardisation organisations

The project representative agreed with all of the options presented above, and felt that it would also be useful to have clear rules on availability and access to data and how these data are exchanged and shared between the public and private sector.
D.5.4.10. Monitoring and evaluation

The project lead noted that monitoring and evaluation has been discussed by the project team. While it is important to carry out an impact assessment, it has been recognised by the project team that it will be difficult to do. They need data logging in the vehicles to collect evaluation data, which could be an issue with GDPR, as discussed in Section D.5.3.2.

If it is possible, C-Roads Belgium would like to acquire data on the reaction of the user to a service. An example is monitoring whether a driver reduces their speed following speed advice warnings, which could be the result of the identification of a dangerous event.
D.6. **CASE STUDY: C-Roads Austria**

<table>
<thead>
<tr>
<th>Deployment project name/title:</th>
<th>C-Roads Austria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member State:</td>
<td>Austria</td>
</tr>
<tr>
<td>Project start date:</td>
<td>February 2016</td>
</tr>
<tr>
<td>Project end date:</td>
<td>December 2020</td>
</tr>
<tr>
<td>Implementing body:</td>
<td>ASFINAG⁴⁶</td>
</tr>
<tr>
<td>Partners:</td>
<td>None</td>
</tr>
<tr>
<td>Location of pilot(s):</td>
<td>Rhine-Danube Corridor: Vienna to Salzburg motorway, Vienna area, Innsbruck area, Greater Graz area</td>
</tr>
<tr>
<td>Project scope - Number of vehicles:</td>
<td>Not known – automotive industry providing vehicles to test the infrastructure</td>
</tr>
<tr>
<td>Project scope - Length of roads (number of RSUs):</td>
<td>300km of motorway; 25 C-ITS stations in operation</td>
</tr>
<tr>
<td>Services covered</td>
<td>Traffic jam ahead warning, road works warning, weather conditions, in-vehicle signage</td>
</tr>
</tbody>
</table>

**D.6.1. Introduction**

**D.6.1.1. Background**

Austria is committed to developing C-ITS as a means of improving transport safety, efficiency and sustainability. The Austrian C-ITS Strategy⁴⁷ outlines the rationale and objectives for C-ITS development, including coordinated deployment across borders, and extending the development beyond high road level. The Strategy outlines how C-ITS can be implemented in Austria by 2020.

The European Corridor – Austrian Testbed for Cooperative Systems⁴⁸ (ECo_AT) project provides a starting point for C-ITS development in Austria. The project has been running since 2013, led by the Austrian federal motorway operator, ASFINAG⁴⁹, and covers the Rotterdam – Frankfurt/M. – Vienna Corridor. The focus on this route requires cooperation with the Netherlands and Germany, who have signed a Memorandum of Understanding. ASFINAG do not have any partners on this project, however they work closely with the Austrian Ministry of Transport, which they are a subsidiary of, and AustriaTech, which is also a subsidiary of the Ministry.

Eco_AT aims to bridge the gap between research and development and deployment for C-ITS, by defining deployment methods for Day One services with industry partners, and rolling out these services within the C-ITS Corridor.

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⁴⁶ [https://www.asfinag.at/en/](https://www.asfinag.at/en/)
⁴⁹ [https://www.asfinag.at/en/](https://www.asfinag.at/en/)
D.6.1.2. Objectives
The Austrian C-Roads project helps to achieve these objectives by building on the core elements of the Eco_AT project and extending them to a motorway-based network of C-ITS stations in 2020.

ASFINAG plans to install C-ITS units on gantries where they can be accessed without restrictions to traffic flow. The use of mobile roadside units is also planned.

D.6.2. Progress to date
C-Roads Austria now has 25 C-ITS stations in operation. C-Roads Austria is operating this infrastructure, with the automotive industry providing vehicles equipped with the necessary technology to test the services.

C-ITS use cases and technical parameters were specified during the Eco_AT project and have been brought into the C-Roads Austria project, as well as being harmonised with other C-Roads projects through the C-Roads Platform. The specifications have also been shared with 400 recipients worldwide, with many using these specifications in their own C-ITS pilot projects (including in Australia). The specifications have also been approved by the automotive and road operator industry, allowing the project to move past technology and technical discussions, and on to deployment.

D.6.3. Barriers and challenges
D.6.3.1. Security
C-Roads Austria applied the security solution that was developed by C-Roads Germany, both nationally and across the C-ITS Corridor that joins the Netherlands, Germany and Austria. This level of international cooperation helped to create a viable solution. However, extending this at an EU level would require further guidelines from the Commission. A security solution was considered by the project coordinator as key to enabling Austrian C-ITS deployment.

D.6.3.2. Privacy and protection of personal data
Privacy and protection of personal data was not a significant challenge for C-Roads Austria. However, with the General Data Protection Regulation (GDPR) coming into force next year which will regulate for privacy by design, the project coordinator indicated that they are having to adapt the technology which has been designed over the last eight years to take this into consideration.

D.6.3.3. Communication technologies
C-Roads Austria uses ITS 5G as its communication technology. This decision was made eight years ago at the beginning of the Eco_AT project. The project coordinator felt that the other technologies are not yet deployment-ready and require further testing before being used. The currently proven technologies should be capable of achieving the benefits of C-ITS, and can be adapted when newer technologies have been fully tested.

D.6.3.4. Interoperability
C-Roads Austria operates with the aim that a C-ITS environment must cover all vehicles that may be used on a road. However, the project coordinator noted that it was not easy to identify where the boundaries should be drawn in terms of what is included in the C-ITS ecosystem, and what is not. Consequently, delivering full interoperability will be challenging.

50 https://www.c-roads.eu/pilots/core-members/austria/Partner/project/show/c-roads-austria.html
D.6.3.5. Compliance testing

C-Roads Austria was carried out in a local environment with a limited number of stakeholders, so compliance was not a problem.

D.6.3.6. Continuity of services

The project coordinator noted that the C-Roads Platform is ensuring that services are continued across geographical and functional scopes.

D.6.3.7. Coordination

No identified barriers or challenges to date.

D.6.3.8. Enabling environment

No identified barriers or challenges to date.

D.6.4. Views on proposed Delegated Regulation on C-ITS

The interviewees were asked about their opinions and views in relation to a proposed delegated regulation on C-ITS. This section explores these views in more detail.

D.6.4.1. Problem definition

The project coordinator felt that the specific objectives outlined in the problem definition are clear, and that the guideline provided by such objectives are essential to implementing complex systems such as C-ITS.

D.6.4.2. Security

Measures considered for addressing security issues in the Delegated Act include:

- Guidance on Security and Certificate policy
- Definition of Security and Certificate policy in specifications
- Mandate Security and Certificate policy
- Definition of operational functions and governance roles in specifications

The project coordinator considered security a key issue from both a regulatory and technical point of view, in deciding which solution is used. They noted that a security framework is required at an EU level based on the findings published by the C-Roads Platform. One caveat is that any security framework must be updated regularly considering new technologies, to ensure technology neutrality. The project coordinator was not sure how such regular updates would be implemented in the Delegated Act.

The security policy developed by the C-ITS Platform has been agreed with the automotive industry and various suppliers. The project coordinator felt that this policy should be replicated as an Annex to the Delegated Act, with the security policy identified as mandatory for any C-ITS deployment. Making this mandatory will ensure interoperability, which is a key aim for C-ITS.
**D.6.4.3. Privacy and protection of personal data**

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<td>• Mandate privacy IA on C-ITS data controller (art. 35 GDPR)</td>
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</table>

The issues around privacy and protection of personal data was not considered a problem when sending information to the vehicles from the infrastructure (V2I), but is an issue when receiving information from vehicles or concerning vehicle to vehicle (V2V) applications.

The project coordinator felt that the Delegated Act needs to answer all the open questions to ensure that vehicle manufacturers have clear guidance before deploying the technology. One such question concerns the user providing consent for their data to be used. The project coordinator questioned whether this consent will be given for the vehicle, or for each use case. The Delegated Act needs to provide specific guidance which removes the possibility of variation in interpretation by Member States. For EU-wide deployment and interoperability, the grounds for approval must be the same.

Overall, the project coordinator thought that there is not yet a straightforward solution to the privacy issues, compared to the solution that has been found with respect to security. The C-ITS Expert Group are currently discussing these issues, but may form a separate group within the C-Roads Platform which is potentially the best place to solve these issues as many Member States are already involved.

**D.6.4.4. Communication**

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Compatibility is often used to mean the ability of different technologies to exist together without interfering with each other. The project coordinator noted that the focus needs to be on interoperability, not compatibility. C-ITS services need to be able to communicate across technologies, so that vehicles with ITS-G5 and other technologies can still understand each other.

A hybrid approach to communications was considered acceptable, with short range communications currently using ITS-5G and long-range communications using 3G/4G.
When other technologies become available and have been fully tested, they must be interoperable, not just compatible.

According to the project coordinator, some stakeholders are still neglecting to ensure interoperability and backwards compatibility between communication technologies, so this needs to be further highlighted in the Delegated Act.

The project coordinator did not think that providing a functional description and technical standards for communication technologies was enough to ensure interoperability; a technical profile is required in addition (this is specified as an option under interoperability). The functional description was considered the least important part of this, as it leaves significant flexibility in implementation. A reference to the technical standards and a technical profile was considered most important, as well as embedding the principles of Annex II of the ITS Directive.

### D.6.4.5. Interoperability

<table>
<thead>
<tr>
<th>Measures considered for helping to ensure interoperability in the Delegated Act include:</th>
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</thead>
<tbody>
<tr>
<td>• Definition of technical C-ITS communication profiles in specifications</td>
</tr>
<tr>
<td>• Functional description of Day 1 services in specifications</td>
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</table>

As with communications compatibility, the project coordinator stressed the importance of technical profiles to ensure interoperability. Functional descriptions allow significant flexibility in the interpretation. Therefore, the definition of technical C-ITS communication profiles in specifications was considered essential, while the function description is optional.

### D.6.4.6. Compliance testing

<table>
<thead>
<tr>
<th>Measures considered for compliance assessment in the Delegated Act include:</th>
</tr>
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<tbody>
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<td>• Definition of common minimum requirements for deployment of Day 1 C-ITS services in specifications</td>
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<td>• Definition of compliance assessment process for Day 1 C-ITS services in specifications</td>
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<td>• Ensure consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.</td>
</tr>
</tbody>
</table>

The project coordinator suggested that compliance at an EU level for Day 1 C-ITS services may be carried out through self-assessment. However, a more rigorous approach may be required as more complex environments and services are added (Day 1.5+).

The self-assessment could be carried out at a local level to test for compliance with the Delegated Act. A further suggestion was that the security certificate required to be part of the C-ITS system could include compliance with the technical aspects of the system, as presented above in the third bullet point.

The project coordinator also considered the definition of common minimum requirements to be required, while the definition of the compliance assessment process would not be sufficient to ensure a common assessment process. Ensuring backwards
compatibility of new services and/or technologies with already deployed services was also seen important, as backward compatibility is essential to C-ITS.

D.6.4.7. **Continuity of services**

Measures considered for helping to ensure continuity of services in the Delegated Act include:

- Definition of Day 1 services in specifications
- Functional description of Day 1 services in specifications
- Reference (prioritise) deployment of Day 1 services
- Mandate combined deployment of Day 1 services

As mentioned above for compatibility and interoperability, the project coordinator considered that technical specifications and technical profiles for Day 1 services are required. Providing both ensures that all stakeholders comply.

D.6.4.8. **Coordination**

Measures considered for addressing coordination issues in the Delegated Act include:

- Establishment of EU governance bodies (C-ITS governing body, C-ITS supervision body, compliance assessment bodies)
- Establishment of EU policy authorities (privacy policy authority, security policy authority, certificate policy authority)
- Establishment of EU operational bodies (trust list manager, C-ITS point of contact, EU root certification authorities)

The project coordinator felt that this topic has not been discussed much at this point. The discussion has focused on the technical aspects of C-ITS deployment, which is a precursor to discussion of governance mechanisms.

D.6.4.9. **Enabling environment**

Measures considered for addressing enabling environment issues in the Delegated Act include:

- Policy advice through stakeholder platform
- Programme support action (PSA) under the Connecting Europe Facility (CEF) for the set-up of common EU elements
- Requirements for the exchange of best practice
- Memorandum of Understanding (MoU) in a ´bottom-up´ approach in which stakeholders could drive activities and initiatives
- Funding for deployment projects
- Funding / coordination of research
- EU deployment coordination
- An agreement on access to selected, specified data for C-ITS services between all relevant public and private stakeholders
- Mandate for standardisation organisations

The project coordinator felt that all the actions currently being pursued by the European Commission are creating an enabling environment. This includes funding projects through CEF, and coordinating Member State activities to ensure sharing of information and interoperability. The project coordinator suggested that the Commission should...
continue with their current activities in this area, and respond to new issues as they develop.

D.6.4.10. Other discussion points

Regarding the impacts on SMEs related to C-ITS project deployment, the project coordinator thought that the new information made available by C-ITS will lead to start-ups using this information in innovative ways not yet perceived by road operators. Larger organisations were felt to be less flexible than SMEs and therefore less able to take advantage of new ideas.

When asked if any issues have arisen from Member States being at different stages of deployment, the project coordinator noted that no issues had been found so far. The front runners in C-ITS deployment are progressing along the right lines, and can accelerate deployment in other Member States by creating technical specifications and profiles.

D.6.4.11. Monitoring and evaluation

The project coordinator did not have a view on who should be responsible for monitoring and evaluation.
CASE STUDY: C-Roads Czech Republic

<table>
<thead>
<tr>
<th>Deployment project name/title:</th>
<th>C-Roads Czech Republic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member State:</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>Project start date:</td>
<td>February 2016</td>
</tr>
<tr>
<td>Project end date:</td>
<td>December 2020</td>
</tr>
<tr>
<td>Implementing body:</td>
<td>Road Motorway Directorate of the Czech Republic, The Ministry of Transport</td>
</tr>
<tr>
<td>Partners:</td>
<td>AŽD Praha, ČVUT (Czech Technical University in Prague), INTENS Corporation, O2 Czech Republic, T-Mobile Czech Republic, České dráhy (operator of the national railway network and 1st class roads network), SŽDC (operator of the nation-wide and regional railway infrastructure owned by the state) and Brněnské komunikace (operator of the street network of the Brno city).</td>
</tr>
<tr>
<td>Location of pilot(s):</td>
<td>Rhine-Danube Corridor: Munich/Nuremberg-Prague, Orient-East Med Core Network Corridor: Prague-Brno, Urban areas of Plzen, Brno and Ostrava</td>
</tr>
<tr>
<td>Project scope - Number of vehicles:</td>
<td></td>
</tr>
<tr>
<td>Project scope - Length of roads (number of RSUs):</td>
<td>200 km of Core Network Corridors and connected municipalities motorways;</td>
</tr>
<tr>
<td>Services covered</td>
<td>Hazardous location notification, road works warning, emergency vehicle approaching, slow or stationary vehicle(s), weather conditions, in-vehicle signage, signal violation/intersection safety, probe vehicle data</td>
</tr>
</tbody>
</table>

Introduction

D.7.1. Background

In preparation for the development of autonomous and connected vehicles over the next 5 years, the Czech Republic has launched a C-Roads project. This project is building on others such as “BaSIC” and the “C-ITS Corridor” along the Prague motorway, which was completed in summer 2017. This project deployed along 50 km of motorway and includes an ITS-G5 RSU every 2 km. These projects can be viewed as phase zero for C-Roads Czech Republic.

C-Roads Czech Republic will deploy C-ITS services across motorways, urban nodes and a unique pilot site focused on verifying the use of C-ITS for enhancing railway crossing safety, aiming to prevent collisions between trains and road vehicles. A hybrid communication approach using ITS-G5 and 4G mobile networks will be used to provide the services.

References:

51 https://www.rsd.cz/wps/portal/
52 http://www.mdcr.cz/?lang=en-GB
D.7.1.2. Objectives

The project has three objectives:

- Achieve interoperability at a European level by deploying C-ITS services to EU standards.
- Verify coexistence, reliability, security and functioning of the mutual linking between ITS-G5 and LTE-V communication technologies.
- Identify ways of preventing collisions between trains and road vehicles using C-ITS services.

D.7.2. Progress to date

C-Roads Czech Republic is made up of five phases, each with a partner responsible for deployment. At the time of writing, the project was at the bidding stage in which it was procuring equipment for the state administration to deploy. The main organisational achievement to date was the development of the consortium and the signing of the consortia agreement. The project had also moved towards adopting the C-Roads Platform specification, which are crucial for any deployment.

The C-Roads specification follows all of these standards. As there are potential issues where the standards can be interpreted in different ways, the C-Roads platform is also harmonising the technical specification relating to the application of the standards.

D.7.3. Barriers and challenges

D.7.3.1. Security

The public key infrastructure (PKI), which is defined at a high level within the C-Roads Platform, could be applied within the project but the detail regarding the deployment of the services and the technology itself is missing. As a result, some countries are using their own approach. The project representative believed that the PKI’s detail on deployment needs to be improved and harmonised, but noted that this was being addressed by Task Force 1 of the C-Roads Platform.

At the time of writing, the work on security within the C-Roads Platform was mainly focused on ITS-G5, but within the project they were looking at how to create a secure connection at the standard LTE connection level.

In June 2017, the C-Roads Platform released new security documents that have been analysed by security experts within the project. A working group has been set up within the project to focus on security, which was testing suitable security technology that had been identified. A difficulty that they had found was the requirement from the C-ITS platform to use two families of coding, one of which is quite common but the other is less common (EACA). This requires very secure hardware modules, which may require large investments to update. This would reduce the sustainability of the technology that is being deployed.

The project representative is hopeful that there would be wider benefits to the other members of the platform from their work on security.

D.7.3.2. Privacy and protection of personal data

As the pilot is mainly focused on vehicles and people who know that they are part of the project, privacy and data protection has been less of an issue; no member of the public are involved in the pilot. The project was mainly testing potential use cases, which included a consideration of the benefits for the users and their data protection needs. While they are aware of upcoming requirements, such as those of the GDPR, the focus of the pilot is on justifying the use cases and testing the technology.

Once the services and the benefits have been defined, the project will look at how these can be deployed safely and then look at the data privacy needs for these services,
particularly to identify which elements of the various use cases are classified as private data. The project is not yet clear how they will implement the GDPR’s requirements next year. The fact that the project will have identified the data privacy requirements and needs of the wide range of stakeholders will mean that the developed solutions will be valuable to others.

D.7.3.3. Communication technologies

The debate around which communication technology will be preferred is a big issue. In this project, they have tested ITS-G5 across three channels and they are now looking into a hybrid combination providing short and long-distance coverage. They began with ITS-G5 and have now added LTE through existing telecommunication providers. Their ambition is to test LTE-V (with T-Mobile) with ITS-G5 deployment by creating a software stack capable of receiving data from both communication technologies. In this respect, they are following the technological neutrality requirement by operating both of these technologies.

The project will deploy LTE-V communication technology in use cases where ITS-G5 was not available, while ensuring that this technology will not interfere with the tolling communication waveband (5.8 GHZ).

A project representative stated that ‘hybrid communication’ needed to be clearly defined before the project was able to introduce different software stacks to handle different communication technologies.

D.7.3.4. Interoperability

The project team have tested hardware from different suppliers and as they follow the same specifications, this seemed to be sufficient to ensure interoperability.

D.7.3.5. Compliance testing

Within the project, there have been no issues with compliance with respect to ITS-G5. However, the project team was not yet clear how to carry out a compliance assessment for a hybrid communications system. It was suggested that there might need to be a national authority to manage this.

Within the project, processes and guidance for compliance assessment will be developed and they will explore how the compliance process can be harmonised with other countries.

D.7.3.6. Continuity of services

The project team has not yet encountered any issues as the project is at an early stage of deployment. The only potential issue that has been identified to date is the potential for discontinuity of services involving traffic lights, as not all will be able to provide messages for GLOSA and smart map.

D.7.3.7. Coordination

In the project, there has been effective coordination because of the frequent communication between the stakeholders. There have been no issues so far.

D.7.3.8. Enabling environment

No issues or challenges were identified by the project representative.

D.7.4. Views on proposed Delegated Regulation on C-ITS

D.7.4.1. Problem definition

No views were expressed by the project representative.
D.7.4.2. Security

<table>
<thead>
<tr>
<th>Measures considered for addressing security issues in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Guidance on Security and Certificate policy</td>
</tr>
<tr>
<td>• Definition of Security and Certificate policy in specifications</td>
</tr>
<tr>
<td>• Mandate Security and Certificate policy</td>
</tr>
</tbody>
</table>

Definition of operational functions and governance roles in specifications

The project representative emphasised that security needs to be addressed quickly to enable wider deployment and that for autonomous driving this will be more of a challenge. He believed that an agreed approach at the EU level would be key to this.

Of the options listed, the project representative believed that at the minimum there needed to be a definition of a security and certificate policy, although he thought a mandate was the best option.

D.7.4.3. Privacy and protection of personal data

<table>
<thead>
<tr>
<th>Measures considered for addressing privacy and data protection issues in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Guidance on protection of personal data and privacy policy by design and by default</td>
</tr>
<tr>
<td>• Include reference to GDPR and e-privacy in specifications</td>
</tr>
<tr>
<td>• Requirement for a Data Protection Impact Assessment (IA) in accordance with the GDPR</td>
</tr>
<tr>
<td>• Definition of principles for the practical implementation of the GDPR in C-ITS in specifications</td>
</tr>
<tr>
<td>• Mandate privacy policy in specifications</td>
</tr>
<tr>
<td>• Mandate privacy IA on C-ITS data controller (art. 35 GDPR)</td>
</tr>
</tbody>
</table>

The project representative thought that including a reference to the GDPR and e-privacy requirements in the specifications should be the minimum. His preferred option would be a version of a requirement for a Data Protection Impact Assessment in accordance with the GDPR, but without the reference to a data protection IA, e.g. a 'requirement for data to be set out in the specifications in accordance with the GDPR'.

He was not sure about the need for anything to be mandatory at this stage, as within the project they had not yet defined which elements should be viewed as private and personal data. He also considered that it would be a challenge to monitor such a mandate.

D.7.4.4. Communication

<table>
<thead>
<tr>
<th>Measures considered for ensuring communication compatibility in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Technology neutrality of spectrum use</td>
</tr>
<tr>
<td>• Reference technical standards</td>
</tr>
<tr>
<td>• Embed principles of Annex II of ITS Directive (e.g. interoperability, backward compatibility)</td>
</tr>
<tr>
<td>• Mandate technical standards</td>
</tr>
<tr>
<td>• Functional description of Hybrid Communication in specifications</td>
</tr>
<tr>
<td>• Mandate mature communication technologies (with exception for pilot technologies, cf. EETS Directive)</td>
</tr>
</tbody>
</table>
Within a Delegated Act, the project representative thought that the neutrality of spectrum use and functional description of hybrid communication were needed. However, he did not consider the need for a mandate of technical standards at this point in time.

D.7.4.5. **Interoperability**

Measures considered for helping to ensure interoperability in the Delegated Act include:

- Definition of technical C-ITS communication profiles in specifications
- Functional description of Day 1 services in specifications

The project representative believed that the work of the C-Roads Platform was contributing to ensuring interoperability, although he noted that harmonisation was an important consideration in the interoperability of use cases. If use cases were not harmonised, it becomes much harder to achieve technical interoperability.

The project representative understands that the European Commission will base the Delegated Act on the outcomes of C-Roads Platform and the C-ITS Platform; he highlighted that this needed to include the definition of both the technical profiles and the functional descriptions (i.e. both options listed).

D.7.4.6. **Compliance testing**

Measures considered for compliance assessment in the Delegated Act include:

- Definition of common minimum requirements for deployment of Day 1 C-ITS services in specifications
- Definition of compliance assessment process for Day 1 C-ITS services in specifications
- Requirement for any new C-ITS station to fulfil the compliance assessment criteria to be part of the C-ITS security trust model
- Ensure backward compatibility of new services and/or technologies with already deployed services
- Ensure consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.

The project representative thought that a definition of the compliance assessment process, the requirement for any new C-ITS station to fulfil the compliance assessment criteria, and the ensuring of backward compatibility of new services and/or technologies with already deployed services were required, but that the requirement for C-ITS stations should also refer to ‘existing’ stations as well as to ‘new’ ones.

D.7.4.7. **Continuity of services**

Measures considered for helping to ensure continuity of services in the Delegated Act include:

- Definition of Day 1 services in specifications
- Functional description of Day 1 services in specifications
- Reference (prioritise) deployment of Day 1 services
- Mandate combined deployment of Day 1 services

The project representative thought that the definition and the functional description of Day 1 services in the specification were most important; again, he did not think that a
mandatory measure was possible at this stage. Within the project, they were also interested in Day 1.5 services, such as parking services, in addition to Day 1 services. Therefore, he considered that it was also important for Day 1.5 services to be defined and would like to see a reference to these in the options.

### D.7.4.8. Coordination

Measures considered for addressing coordination issues in the Delegated Act include:

- Establishment of EU governance bodies (C-ITS governing body, C-ITS supervision body, compliance assessment bodies)
- Establishment of EU policy authorities (privacy policy authority, security policy authority, certificate policy authority)
- Establishment of EU operational bodies (trust list manager, C-ITS point of contact, EU root certification authorities)

The project representative thought that the three options above were complementary and that all three were needed, although he identified governance bodies as being most important. However, he noted that these functions did not have to be carried out by separate agencies as they could potentially be combined into one body.

He also expressed a concern that there was an inconsistent message coming from different DGs within the Commission regarding support of particular C-ITS communication technologies. The representative highlighted that because C-ITS deployment is not mandatory, it is important for there to be a common aim and common agenda across all the DGs within the Commission.

### D.7.4.9. Enabling environment

Measures considered for addressing enabling environment issues in the Delegated Act include:

- Policy advice through stakeholder platform
- Programme support action (PSA) under the Connecting Europe Facility (CEF) for the set-up of common EU elements
- Requirements for the exchange of best practice
- Memorandum of Understanding (MoU) in a ‘bottom-up’ approach in which stakeholders could drive activities and initiatives
- Funding for deployment projects
- Funding / coordination of research
- EU deployment coordination
- An agreement on access to selected, specified data for C-ITS services between all relevant public and private stakeholders
- Mandate for standardisation organisations

The project representative outlined a number of factors that contributed to the creation of a good enabling environment. The lead from the European Commission in the C-ITS strategy was important, as well as a commitment from the automotive industry. It is also important for there to be a common approach and set of activities from different DGs in terms of deploying C-ITS, which, as noted above, does not always appear to the case. Dissemination of the results from different EU projects is also important, as it can help to inform discussions with stakeholders and potential interested partners.

Funding for deployment projects was also important as if a project had some financial backing, it was easier to encourage commitment from other interested parties. Coordination of research was important at the current time, but it would not be possible
or necessary to continue this once many projects were being undertaken. Programme support action under CEF and a mandate for standardisation organisations were also considered to be important.

The project representative thought that it would be beneficial to have a common library or knowledge sharing platform to bring together C-ITS information in order to make this accessible to a wider audience such as stakeholders in cities. This is linked to the need to improve the marketing of the technology and to attracting investment and interest.

The main challenge was bringing together the key stakeholders, including the state, and the telecommunications and automotive sectors. If these organisations could work together and develop attractive business cases, deployment would happen. If the business case was not strong enough for the private sector then mandating some services may be needed.

**D.7.4.10. Other discussion points**

The project representative did not see it as an issue that there were different levels of deployment between Member States. Newcomers were able to learn from the experiences of front runners who had invested time and money into the field of C-ITS. For example, the C-Roads Czech Republic project team was using specifications that had been developed elsewhere (ECo-AT, French and Dutch projects). These specifications were based on standards and were therefore relatively similar and transferable.

**D.7.4.11. Monitoring and evaluation**

No views were expressed by the project representative.
## D.8. CASE STUDY: C-Roads France

<table>
<thead>
<tr>
<th>Deployment project name/title:</th>
<th>C-Roads France</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member State:</td>
<td>France</td>
</tr>
<tr>
<td>Project start date:</td>
<td>February 2016</td>
</tr>
<tr>
<td>Project end date:</td>
<td>December 2020</td>
</tr>
<tr>
<td>Implementing body:</td>
<td>French Ministry of Transport$^{54}$</td>
</tr>
<tr>
<td>Partners:</td>
<td>SCOOP@F, consisting of:</td>
</tr>
<tr>
<td></td>
<td>Public road operators (DIRs Est, Centre-Est, Atlantique, Ouest)</td>
</tr>
<tr>
<td></td>
<td>ASFA: concessionaries road operators (APRR$^{55}$, SANEF$^{56}$, and VINCI autoroutes$^{57}$)</td>
</tr>
<tr>
<td></td>
<td>Urban nodes (Strasbourg Eurometropole$^{58}$, Bordeaux Metropole$^{59}$)</td>
</tr>
<tr>
<td></td>
<td>Car manufacturers (Renault$^{60}$, PSA Group$^{61}$)</td>
</tr>
<tr>
<td></td>
<td>Research institutes (CEREMA$^{62}$, IFSTTAR$^{63}$)</td>
</tr>
<tr>
<td></td>
<td>Universities and research institutions (Université d’Auvergne Clermont-Ferrand, Université de Reims Champagne-Ardenne, Institut Mines Télécom (Telecom ParisTech$^{64}$))</td>
</tr>
<tr>
<td></td>
<td>Security experts (IDNomic$^{65}$)</td>
</tr>
<tr>
<td></td>
<td>Mobility labs (Car2road$^{66}$, Transpolis$^{67}$)</td>
</tr>
<tr>
<td>Location of pilot(s):</td>
<td>Regions in North-East, Centre-East, West and South-West France</td>
</tr>
<tr>
<td>Project scope - Number of vehicles:</td>
<td>3,000 test vehicles</td>
</tr>
<tr>
<td>Project scope - Length of roads (number of RSUs):</td>
<td>2,000 km.</td>
</tr>
<tr>
<td>Services covered:</td>
<td>The C-ITS services deployed include priority services of road works warning, information about current interventions of road maintenance agents, and on-board signalling of hazardous and dangerous events.</td>
</tr>
</tbody>
</table>

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$^{54}$ www.ecologique-solidaire.gouv.fr/
$^{55}$ www.aprr.fr/
$^{56}$ www.sanef.com/
$^{57}$ www.vinci-autoroutes.com/fr
$^{58}$ www.strasbourg.eu/en
$^{59}$ www.bordeaux-metropole.fr/
$^{60}$ https://group.renault.com/en/
$^{61}$ https://www.groupe-psa.com/en/
$^{62}$ http://www.cerema.fr/
$^{63}$ http://www.ifsttar.fr/en/welcome/
$^{64}$ https://www.telecom-paristech.fr/eng
$^{65}$ https://www.idnomic.com/?lang=en
$^{66}$ http://www.car2road.com/en
$^{67}$ http://www.transpolis.fr/en/
D.8.1. Introduction

D.8.1.1. Background

C-Roads France is a C-ITS pilot project that is taking place in four locations in France. The project is being delivered by the same consortium involved in the SCOOP@F C-ITS pilot projects that have been running since 2014. The SCOOP@F projects are aimed at testing communication between road infrastructure and vehicles using both ITS-G5 and cellular communications standards and cover 2,000km of roads and 3,000 vehicles over five sites. The C-Roads France project will add a few more vehicles to this, as well as expanding the roadside coverage to North-East, Centre-East, West and South-West France.

SCOOP@F Part 1 ran from 2014 to 2015 and involved the study and pre-deployment phase of the project. Part 2 started in 2016 and runs till the end of 2018, being aimed at validating the findings of Part 1 on open roads, and across borders. The C-ITS services deployed include priority services of road works warning, information about current interventions of road maintenance agents, and on-board signalling of hazardous and dangerous events.

C-Roads France builds on the SCOOP@F projects, adding two new types of end-user services: services in the urban environment and at the urban/interurban interface, as well as and traffic information services. C-Roads France will also enhance and extend test fields on sections of the TEN-T Core Network, including key bottlenecks, black spots, and interfaces with urban nodes. Two car manufacturers are involved in the project, which will help to ensure that the infrastructure meets the needs of future vehicle fleets.

The consortium behind C-Roads France was assembled to bring together the various stakeholders involved in C-ITS deployment. Vehicle manufacturers and road operators were both involved to develop the vehicle and infrastructure applications in a harmonised approach. The consortium also involves technical experts and academics in the field of security and C-ITS.

The pilot aims to maintain a market neutral approach by not including any equipment manufacturers in the consortium. This allows the vehicle manufacturers and road operators to procure the equipment from the most suitable source, rather than being tied to a single supplier. On the vehicle-side, manufacturers work with their preferred suppliers, while on the road-side, there are tenders for new equipment suppliers for C-ITS applications.

D.8.1.2. Objectives

The C-Roads France project has three main objectives:

- To increase technology penetration rates in the current vehicle fleet by developing a C-ITS smartphone app for early V2I services;
- To reach a seamless continuity of services at the urban/interurban interface; and
- To encourage agreement amongst Member States on strategic topics, such as security, as part of the C-Roads Platform.

D.8.2. Progress to date

The SCOOP@F project was launched in 2014, with the specification for the system and its components being set in 2015 and validation and the start of vehicle production beginning in 2016. Almost all the roadside equipment is now deployed across 2,000 km of roads, with the first Renault and Groupe PSA (Peugeot/Citroen) vehicles in the deployment phase. The project will run until 2018.

As discussed above, the functional and technical system specifications have been developed and the evaluation process and validation tools for equipment have been agreed upon. This process of validation includes checks on scalability, ETSI (European
Telecommunications Standards Institute) conformance and communication between RSUs (Road Side Unit) and the C-ITS central station. Furthermore, the whole system architecture is now running with prototypes and HMI-enabled vehicles being deployed. Perhaps most significant is the advances made in C-ITS security: a security architecture has been developed for SCOOP@F that did not exist before.

The C-Roads France project will build on these successes, running until the end of 2020. The project is in the specification phase, in which the project partners are developing specifications for the new C-ITS services and the smartphone app. The project team are currently focusing on the hybrid architecture required to integrate both ITS-G5 and cellular communications protocols. The project has involved a number of SMEs as equipment providers of roadside units (RSUs) and on-board units (OBUs). By being involved in the project, these companies have been able to scale up their manufacturing and gained valuable knowledge and experience on the deployment of C-ITS services.

At this early stage C-Roads France can report two main achievements. Firstly, as part of the project the ITS European Congress was organised and held in Strasbourg, which included a demonstration of SCOOP@F vehicles that are being deployed. This demonstrated that the achievements of SCOOP@F can be implemented in other places. The conference was full and attracted a lot of interest leading to the dissemination of many of SCOOP@F’s key achievements and learning points to a wide audience. The second main achievement is the agreement of a common deliverable between SCOOP@F, C-ROADS France and the French partners involved in the InterCor project. Together, these French stakeholders have developed a common catalogue of C-ITS services for France. As such, a European template has been developed and this has been used as the basis for a harmonised functional description of the services deployed.

One project stakeholder indicated that a similar agreement on the functional description of C-ITS services should be part of the Delegated Act and that the harmonisation completed in the C-Roads France project is a good example to follow.

D.8.3. Barriers and challenges

This section considers the barriers and challenges that have been faced by the deployment project. In this case, the majority of barriers relate to the SCOOP@F project as C-Roads France is still at an early stage. Where possible, the implications for national and wider European deployment have been discussed.

D.8.3.1. Security

The project team worked with the French national IT security agency (ANSSI) to develop a novel system to ensure the security of services delivered. An analysis was conducted and a Public Key Infrastructure (PKI) was designed successfully, but the process presented a number of challenges. For national scale deployment, there would first need to be an upgrade of the current security specifications including the development of a national PKI. The French state would need to tender for the development of this PKI, which would have to be scalable for many vehicles. A similar process would need to be carried out in each Member State for EU wide deployment.

D.8.3.2. Privacy and protection of personal data

The project has found from experience that obtaining authorisation from the data protection agency, when selling vehicles to customers, is typically a long process. At a national scale, obtaining authorisation would present several challenges:

- The General Data Protection Regulation (GDPR) legal framework has ‘privacy by default’ as a core principle. It will therefore have a major impact on the design of the C-ITS security system.
- In projects such as C-Roads France, the consortium can be held responsible by the end user on issues including privacy. In real-life deployment of services,
the system will be owned and operated by different parties and so no one entity is responsible for the entire system.

- In a wide-scale deployment scenario, there is a risk of transmitted data being captured by ‘sniffers’ and used for other purposes. As much of the data is personal in nature, this is an important open issue that needs to be addressed by any potential Delegated Act.

**D.8.3.3. Communication technologies**

The issue of incompatible communication technologies is not something that the C-Roads France team have faced but it is an issue that would be relevant to national and wider EU deployment, and could present a major challenge to C-ITS in the next few years. The issue is related to the new cellular-based short-range technology (LTE-V2X) that is operating in the same frequency band as ITS-G5. The information that the project team have received from their partners, who have tried to use the two short-range technologies together, is that each technology interferes with the other, making them incompatible under the current standards. Nevertheless, the project leader has been involved in the CPT mandate, which suggests that one possible solution to this issue could be to look at an evolution of the standard to ensure the non-interference between both technologies, rather than interoperability. If such a solution is not adopted, the potential interference could cost lives, so this is clearly a very important issue and the project leader was concerned that the CPT will not be able to find a solution, or that the solution would decrease the efficiency of the system. Two alternative solutions that were suggested include:

- Choosing one of the technologies in preference to the other, rather than waiting for years for the market to decide; or
- Splitting the frequency bands in which the technologies operate, to allow both to operate simultaneously.

The uncertainty in which communication technologies will be used was seen as a key issue preventing many vehicle manufacturers from deploying C-ITS services.

**D.8.3.4. Interoperability**

The project team found that agreeing on specifications that were suitable for both road operators and car manufacturers was a big challenge. Presently, the standards alone are not enough to ensure interoperability and so additional specifications are required. The project team is developing a French specification but this would also need to be harmonised at the European level.

**D.8.3.5. Compliance testing**

There are a number of systems that must work together, including the on-board unit, the roadside equipment, the back-office systems and the PKI. As well as being interoperable, there must also be a harmonised system in place to ensure that upgrades happen across the system and do not impact the ability of the system components to work together. At the project level, the team was able to bring all the stakeholders and developers together to test all combinations of systems and updates. However, at the national level this cannot be easily achieved and so there must be a compliance assessment standard/process to ensure that, for example, off-the-shelf units will be interoperable with other systems and system components in use on the market. The project leader stated that this issue must be addressed in the Delegated Act and that a specification may not be sufficient to ensure wider interoperability.

**D.8.3.6. Continuity of services**

No additional barriers or challenges identified to date.
D.8.3.7. **Coordination**
No identified barriers or challenges to date.

D.8.3.8. **Enabling environment**
No identified barriers or challenges to date.

D.8.3.9. **Others**
No identified barriers or challenges to date.

D.8.4. **Views on proposed Delegated Regulation on C-ITS**
The interviewees were asked about their opinions and views in relation to a proposed delegated regulation on C-ITS. This section explores these views in more detail.

D.8.4.1. **Problem definition**
The project lead identified two points that he considered are not being sufficiently emphasised. The first is the chicken-and-egg problem that exists between the road operators and the vehicle manufacturers, which is potentially not fully addressed in the problem tree. Specifically, despite investment in roadside infrastructure, vehicle manufacturers are not seen as taking sufficient action to support the deployment of C-ITS. Secondly, there is the risk that deployment of C-ITS may occur much later than expected (later than 2019) if stakeholders wait for the market to choose a preferred communication technology.
D.8.4.2. Security

Measures considered for addressing security issues in the Delegated Act include:

- Guidance on Security and Certificate policy
- Definition of Security and Certificate policy in specifications
- Mandate Security and Certificate policy
- Definition of operational functions and governance roles in specifications

It was felt that security is of the utmost importance, but the material to resolve this issue is already available. The work on certificate policy and security architecture undertaken by the C-ITS Platform can be taken and put into the Delegated Act and mandated, providing that there is enough flexibility to update it as often as needed. However, there would still be two other remaining problems: firstly, how to deal with the evolution of security standards; secondly, the security architecture from the C-ITS Platform needs some common elements at the European level, including the development of technical and governance bodies at the European level.

D.8.4.3. Privacy and protection of personal data

Measures considered for addressing privacy and data protection issues in the Delegated Act include:

- Guidance on protection of personal data and privacy policy by design and by default
- Include reference to GDPR and e-privacy in specifications
- Requirement for a Data Protection Impact Assessment (IA) in accordance with the GDPR
- Definition of principles for the practical implementation of the GDPR in C-ITS in specifications
- Mandate privacy policy in specifications
- Mandate privacy IA on C-ITS data controller (art. 35 GDPR)

The work undertaken in the context of the C-ITS Platform on privacy is less mature than that on security. From the project lead’s perspective, the impact of the GDPR has not been assessed sufficiently. In his view, the options listed above for addressing privacy and data protection issues do not address the real issue, which is how the national data protection authorities can authorise deployment and the sale of ITS stations. It is not clear what the legal basis is in the GDPR for transmitting data (e.g. is it based on consent, on law, or on public interest?). One possible solution would be that the Delegated Act becomes the legal basis for the deployment of C-ITS. For example, the act could state that the Commission believes, as a result of the potential benefits to road safety, that it is worth deploying C-ITS without needing consent for each of the services and for each of the C-ITS stations sold. Whether this would solve the problem from the perspective of all stakeholders, including data protection authorities, remains to be seen. However, it is worth adding as an additional option to be considered in the Impact Assessment: “Use the Delegated Act as the legal basis for the exchange of data for enabling C-ITS.”

Of the other options listed, the option to ‘require an IA’ was not considered to be clear. It is unlikely that requiring a vehicle manufacturer or service provider, who are selling C-ITS services, to go through an IA process would be achievable.
D.8.4.4. Communication

Measures considered for ensuring communication compatibility in the Delegated Act include:

- Technology neutrality of spectrum use
- Reference technical standards
- Embed principles of Annex II of ITS Directive (e.g. interoperability, backward compatibility)
- Mandate technical standards
- Functional description of Hybrid Communication in specifications
- Mandate mature communication technologies (with exception for pilot technologies, cf. EETS Directive)

More important than the issue of hybrid communication between short and long-range technologies is the issue of the co-existence of both short-range technologies that are operating on the same 5.9GHz automotive safety frequency band. The project lead thought that it is not a feasible option to have a solution where all ITS stations must have both ITS-G5 and LTE-V2X compatibility. There are some potential options, including having the two technologies use different frequency bands, or splitting the frequency band, and then developing complementary services. However, it was felt that the ultimate solution would require a choice between the two technologies and that without making this choice, the EU may miss out on targeted safety benefits associated with C-ITS.

With respect to hybrid communication for communications outside of the 5.9GHz frequency band, the project lead understood that the Commission is considering mandating that vehicles are fitted with both short and long-range technologies, leaving the choice to the road operator or Member State on which to use. This would not be the project lead’s preferred approach as there are services that are better suited to short range technology and some that are better suited to long range technology. He felt that there is also a need for the right balance between building on mature technologies and not preventing technical progress that could come from later technologies. It is important to have the example of eCall in mind, which is based on 2G networks that are not used any more. The focus should therefore not only be on mature technologies, but should allow flexibility for future technologies.

D.8.4.5. Interoperability

Measures considered for helping to ensure interoperability in the Delegated Act include:

- Definition of technical C-ITS communication profiles in specifications
- Functional description of Day 1 services in specifications

Regarding interoperability, having common specifications is key. The project lead felt both options that are listed above are important. In addition, in order to ensure interoperability at any time, he felt that a way must be found to bring all major stakeholders together at regular intervals in order to ensure that upgrades to all C-ITS systems are undertaken in a synchronous manner. Without this, some equipment could have new versions of the specification running on roads that have old versions of the specification running, which could lead to interoperability issues. He felt that a way to pace deployment and upgrades must be found and there is a need for a governance framework to deliver this. This is important as it may not be feasible to require that any new technology is backward compatible.
D.8.4.6. Compliance testing

<table>
<thead>
<tr>
<th>Measures considered for compliance assessment in the Delegated Act include:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Definition of common minimum requirements for deployment of Day 1 C-ITS services in specifications</td>
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<tr>
<td>• Definition of compliance assessment process for Day 1 C-ITS services in specifications</td>
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<tr>
<td>• Requirement for any new C-ITS station to fulfil the compliance assessment criteria to be part of the C-ITS security trust model</td>
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<tr>
<td>• Ensure backward compatibility of new services and/or technologies with already deployed services</td>
</tr>
<tr>
<td>• Ensure consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.</td>
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</tbody>
</table>

Compliance assessment must not only deal with compliance of the specifications, but must also ensure interoperability. For example, there must be a compliance process in which you take several reference prototypes and test the interoperability between these. If the interoperability of the components of the system with other components is not tested, there may be an issue with interoperability at some point in time. Hence, there needs to be compliance assessment for interoperability; not only assessing compliance with a set of specifications, but as part of a wider system with other components.

D.8.4.7. Continuity of services

<table>
<thead>
<tr>
<th>Measures considered for helping to ensure continuity of services in the Delegated Act include:</th>
</tr>
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<tbody>
<tr>
<td>• Definition of Day 1 services in specifications</td>
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<tr>
<td>• Functional description of Day 1 services in specifications</td>
</tr>
<tr>
<td>• Reference (prioritise) deployment of Day 1 services</td>
</tr>
<tr>
<td>• Mandate combined deployment of Day 1 services</td>
</tr>
</tbody>
</table>

It was noted that it is difficult to see the difference between continuity of services and interoperability, as they are linked. The project lead is not in favour of any geographical prioritisation in terms of deployment, which would be a constraint that would prevent some stakeholders from starting deployment. For example, if deployment is started on the TEN-T network before going into the cities, as long as one of the concessionaires on the TEN-T network has not finished deployment, a city such as Bordeaux might be prevented from deploying C-ITS. This would not be a sensible approach as it would inhibit deployment in some places that are willing to deploy. It was suggested that it should be up to Member States to define their deployment plans with some flexibility. Additionally, France is a decentralised country, as are others in Europe, which means that it is difficult to mandate something on roads that are operated by a local or regional authority.

Referring to the ‘common catalogue of C-ITS services’ in section 1.2, the project leader indicated that a similar agreement on the functional description of C-ITS services should be part of the Delegated Act, and that the harmonisation completed in the C-Roads France project is a good example to follow.
**D.8.4.8. Coordination**

Measures considered for addressing coordination issues in the Delegated Act include:

- Establishment of EU governance bodies (C-ITS governing body, C-ITS supervision body, compliance assessment bodies)
- Establishment of EU policy authorities (privacy policy authority, security policy authority, certificate policy authority)
- Establishment of EU operational bodies (trust list manager, C-ITS point of contact, EU root certification authorities)

The options contain many bodies for compliance assessment and security. However, what is missing is a general coordination body for deployment that monitors the version of the specifications that is deployed in each region and in each type of vehicle, and then tries to coordinate the upgrade of the various elements of the system at the same time. This same body could also review the practical implementation of the Delegated Act, as well as any issues that emerge and a follow-up of the Delegated Act.

**D.8.4.9. Enabling environment**

Measures considered for addressing enabling environment issues in the Delegated Act include:

- Policy advice through stakeholder platform
- Programme support action (PSA) under the Connecting Europe Facility (CEF) for the set-up of common EU elements
- Requirements for the exchange of best practice
- Memorandum of Understanding (MoU) in a ‘bottom-up’ approach in which stakeholders could drive activities and initiatives
- Funding for deployment projects
- Funding / coordination of research
- EU deployment coordination
- An agreement on access to selected, specified data for C-ITS services between all relevant public and private stakeholders
- Mandate for standardisation organisations

It is the project lead’s understanding that the option relating to the PSA is for common security elements only. Regarding the option containing the MoU, it is not clear who this would be between. It needs to be more detailed in order to be able to understand what it means.

**D.8.4.10. Other discussion points**

The project lead feels that the Commission has always had a market-driven approach and has tried to encourage the market to deliver C-ITS based on appropriate business models, without the need for a mandate to deploy. In the US, the intention is to mandate DSRC antennas on new cars. The project lead believes that such options should also be considered in the EU; in his view it needs to be considered whether the EU should stick to the idea of waiting for the market to deploy, or, given the many safety benefits, mandate deployment. He also stated that the ITS Directive is written in a way that makes it difficult to mandate deployment, but the question must be raised.

**D.8.4.11. Monitoring and evaluation**

Pilot projects include an evaluation and while real life deployments will result in the collection of much data, there is unlikely to be a formal evaluation process, unless it is a requirement of the Delegated Acts. Sensors are put in some vehicles in C-Roads France
in order to assess road safety benefits, but this would not be possible in wide-spread deployment. Hence, such a detailed evaluation is out of the scope of the Delegated Act.

Regarding potential monitoring and evaluation of the actual implementation, rather than impacts of C-ITS services, C-ITS by definition is something that is deployed by both road operators and vehicle manufacturers. These are linked, but you cannot have a top-down process where you decide what to deploy where. C-ITS will be deployed based on industry choices, and then people will decide whether to use the services or not. It will be very intricate and therefore difficult to understand whether an evaluation of deployment in different regions is possible. Furthermore, it would be difficult to ask manufacturers to submit figures to the Commission detailing numbers of vehicles sold that are equipped with different services.

It is difficult in practice to monitor and evaluate what has happened on the ground. Some of the other Delegated Acts under the ITS Directive are easier to monitor, e.g. the designation of the national access points. It would be possible to explain that there is some deployment in certain parts of the road network, but no-one has any control over what is happening in different cities, or in terms of car sales.
D.9. **CASE STUDY: C-Roads Germany**

<table>
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<tr>
<th>Deployment project name/title:</th>
<th>C-Road Germany</th>
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<tr>
<td>Member State:</td>
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</tr>
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<td>Project start date:</td>
<td>February 2016</td>
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<tr>
<td>Project end date:</td>
<td>December 2020</td>
</tr>
<tr>
<td>Implementing body:</td>
<td>All organisations are equal partners</td>
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<tr>
<td>Partners:</td>
<td>Hessen Mobil<a href="https://mobil.hessen.de/">68</a> (Hessen pilot site)</td>
</tr>
<tr>
<td></td>
<td>NORDSYS<a href="http://www.nordsys.de/en/">69</a> and OECON Products and Services<a href="http://www.oecon-line.de/en/">70</a>, supported by DLR (Lower Saxony pilot site).</td>
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<tr>
<td></td>
<td>Harmonised by Federal Highway Research Institute (BASt)<a href="http://www.bast.de/EN/Home/home_node.html">71</a></td>
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<tr>
<td>Location of pilot(s):</td>
<td>Hessen: Rhine-Alpine corridor near Frankfurt</td>
</tr>
<tr>
<td></td>
<td>Lower Saxony: North-Baltic and Orient/East-Med corridor near Braunschweig</td>
</tr>
<tr>
<td>Project scope - Number of vehicles:</td>
<td>Not known</td>
</tr>
<tr>
<td>Project scope - Length of roads (number of RSUs):</td>
<td>20 C _ITS safety trailers, 35 ITS roadside stations, and 14 ITS vehicle stations in Hessen</td>
</tr>
<tr>
<td></td>
<td>3 ITS roadside stations in Lower Saxony</td>
</tr>
<tr>
<td>Services covered</td>
<td>Slow or stationary vehicle, road works warning, green light optimal speed advisory, shockwave damping, in-vehicle information/in-vehicle signage service, probe vehicle data</td>
</tr>
</tbody>
</table>

D.9.1. **Introduction**

D.9.1.1. **Background**

C-Roads Germany[72](https://www.c-roads.eu/pilots/core-members/germany/Partner/project/show/c-roads-germany.html) is the evolution of two regional initiatives. The first of these initiatives is the existing test field in Lower Saxony, called the Application Platform for Intelligent Mobility (AIM). AIM has been operating since 2012, as a partnership between the Ministry for Economy, Labour and Transport of Lower Saxony[73](http://www.lowersaxony.de/politics_and_state/state_government/the-lower-saxony-state-government-99165.html), and DLR[74](http://www.dlr.de/dr//en/desktopdefault.aspx/tabid-10002/). The test field is in the city of Braunschweig, and involved the installation of ITS roadside stations that monitor and communicate with vehicles. The platform allowed further research into the development of intelligent mobility services. This work is also part of wider research into automated driving.

The second regional initiative on which C-Roads Germany builds is in Hessen. Here, the development of C-ITS results from a continuation of previous projects as it is a central part of the C-ITS Corridor connecting the Netherlands and Austria. BASt is helping to bring these two regional projects together as a national initiative. The other partners were chosen as part of a bottom-up approach based on the existing relationships between the regional level partners.

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68 https://mobil.hessen.de/
69 http://www.nordsys.de/en/
70 http://www.oecon-line.de/en/
71 http://www.bast.de/EN/Home/home_node.html
72 https://www.c-roads.eu/pilots/core-members/germany/Partner/project/show/c-roads-germany.html
74 http://www.dlr.de/dr//en/desktopdefault.aspx/tabid-10002/
**D.9.1.2. Objectives**

C-Roads Germany will extend the AIM test field to federal roads and motorways between Hannover, Braunschweig and Wolfsburg. The project will implement seven C-ITS services over the two pilot sites and deliver a transferable C-ITS framework, developed from the harmonised findings. This will include the organisational structures needed for development and deployment, a work programme to install the required infrastructure and equipment, and the development of appropriate methods and Public Key Infrastructures (PKI’s) for evaluation and assessment.

The C-Roads Germany project has three main objectives:

- Provide a development pattern for rolling out C-ITS services in Germany in line with EU regulations and standards.
- Demonstrate the long-term viability and scalability of the technology.
- Encourage the automotive industry to install devices in vehicles, which will stimulate end-users to purchase V2X-enabled cars to access the benefits of C-ITS services.

**D.9.2. Progress to date**

The C-ITS Corridor based around Hessen has successfully developed and trialled road works warnings, with this service now being mature enough to roll out in Hessen and other states along the Corridor. These services will be rolled out in all federal states by 2020.

C-Roads Germany involves building on from this work. They are currently working on conceptualising the services, making a deployment plan and tendering for the necessary equipment so that the services will go into operation in two waves at the end of 2018 and the end of 2019. The project now provides a broader bundle of services and has addressed interoperability challenges with other C-Roads partners.

The services provided are:

- Hessen – Road works warning, slow or stationary vehicle, probe vehicle data (Q3 2018)
- Lower Saxony – Slow or stationary vehicle (2018), probe vehicle data, in-vehicle signage (2019)

**D.9.3. Barriers and challenges**

**D.9.3.1. Security**

During the implementation of C-Roads Germany, security is considered to be a very important issue. As result, the project took a prominent role in harmonising the approach to security in the work of the C-Roads Platform. They have worked closely with the C-ITS Platform Working Group on security, as well as with BSI, the German federal agency responsible for information security.

A project partner stated that there are a variety of issues related to security in C-ITS that needed to be resolved, including how long certificates are valid for, and how often they should be reissued. C-Roads Germany managed to overcome these issues using the experience of the partners in dealing with such issues on the automotive side. Within C-Roads Germany, they are operating PKIs for testing security systems. They are aware of the work that is being undertaken at the EU level, which will be managed by the JRC. C-Roads Germany plans to make use of some of these harmonised PKIs, but expects to set up their own in line with the agreed policy.

**D.9.3.2. Privacy and protection of personal data**

C-Roads Germany has had continuous dialogue with the German federal institute for data protection on the issue of privacy and the protection of personal data. The project
partner interviewed was concerned about the potential impact of the GDPR. In particular, he was concerned about the recommendation from the Article 29 Working Party, which is developing guidelines for the implementation of the GDPR, that the default privacy settings for C-ITS systems are that they are switched off. If many C-ITS systems remain switched off by the users, all the work being done to build a C-ITS network would not be able to achieve its goals.

**D.9.3.3. Communication technologies**

While there have been compatibility issues in the past, C-Roads Germany has built on the experience of other projects (including SIM-TD, DRIVE C2X and the C-ITS Corridor) to solve most of their compatibility and integration issues.

C-Roads Germany is using a combination of short-range communication and cellular technologies. A project partner felt that this was important as different technologies offer benefits for different services.

**D.9.3.4. Interoperability**

No Identified barriers or challenges to date.

**D.9.3.5. Compliance testing**

Compliance has been tested within the C-Roads Germany project.

**D.9.3.6. Continuity of services**

No Identified barriers or challenges to date.

**D.9.3.7. Coordination**

No Identified barriers or challenges to date.

**D.9.3.8. Enabling environment**

No Identified barriers or challenges to date.

**D.9.4. Views on proposed Delegated Regulation on C-ITS**

**D.9.4.1. Problem definition**

A project partner emphasised the lack of coordination between relevant bodies. They noted that the cross-cutting nature of C-ITS presents a challenge to ensure that a wide range of stakeholders are engaged in the various processes. At the moment, change management processes are being developed by different sectors, e.g. within the automotive sector and for the deployment of infrastructure. However, C-ITS requires that there be a common change management process for all actors, so rather than just involve the automotive sector or those deploying the infrastructure, these need to be brought together to develop a common process along with actors beyond these industries, such as those in the information technology sector. This process needs to be reflected in the automotive industries’ quasi-standardisation activities that are collaboratively undertaken through Autosar. The C-Roads Platform could help by agreeing the change management process, rather than having to consult all 28 Member States. However, the current rate of change is much greater than that seen over the last few decades, so the change management processes must be developed as quickly as possible.

[75](https://www.autosar.org/)
**D.9.4.2. Security**

Measures considered for addressing security issues in the Delegated Act include:

- Guidance on Security and Certificate policy
- Definition of Security and Certificate policy in specifications
- Mandate Security and Certificate policy
- Definition of operational functions and governance roles in specifications

A project partner highlighted the need for commonly agreed security rules which are applied across all C-ITS deployments, whether this be at the national or level the European level, or between several Member States. The common policy elements that have been agreed in the C-ITS Platform are a good step forward in this respect.

Of the options listed above, a project partner felt that there must be the definition of security and certificate policy in the specifications. Guidance alone would not be sufficient to ensure harmonisation at the European level.

**D.9.4.3. Privacy and protection of personal data**

Measures considered for addressing privacy and data protection issues in the Delegated Act include:

- Guidance on protection of personal data and privacy policy by design and by default
- Include reference to GDPR and e-privacy in specifications
- Requirement for a Data Protection Impact Assessment (IA) in accordance with the GDPR
- Definition of principles for the practical implementation of the GDPR in C-ITS in specifications
- Mandate privacy policy in specifications
- Mandate privacy IA on C-ITS data controller (art. 35 GDPR)

A project partner suggested that there might be special legal basis for a European requirement on privacy in C-ITS. On the basis of the C-ITS Platform Phase II Final Report, the Article 29 Working Party (WP) opinion and the Draft ePrivacy regulation the options to cope with privacy are either ‘user consent’ or ‘public interest’. They did not think it was possible to build a C-ITS network based on the earmarking of data use (i.e. who, when and where the data can be used) or on the requirement that the default setting is “switched off” (i.e. transmitting no data, as stated in the Article 29 WP opinion).

The first phase of C-ITS services focuses on information services provided by infrastructure, which do not have any privacy issues. The issues only arise when data is transmitted from vehicles and when that data is shared. The project partner thought that an option might be to anonymise the data before it is received, with the assistance of the OEMs.
D.9.4.4. Communication

Measures considered for ensuring communication compatibility in the Delegated Act include:

- Technology neutrality of spectrum use
- Reference technical standards
- Embed principles of Annex II of ITS Directive (e.g. interoperability, backward compatibility)
- Mandate technical standards
- Functional description of Hybrid Communication in specifications
- Mandate mature communication technologies (with exception for pilot technologies, cf. EETS Directive)

A project partner considered that embedding the principles of Annex II of the ITS Directive was important as interoperability and backwards compatibility are important. Technical profiles of the technologies are also required as technical standards on their own still leave a lot of options for how the technology is implemented. The C-Roads projects are currently working together to this end to create the necessary profiles.

The project partner raised concerns about promoting a specific technology over others. Technological progress means that new (and potentially improved) technologies are always available in the future. He felt that C-ITS services should be implemented with the technologies currently available and then a switch should be made to a new technology when it becomes available.

D.9.4.5. Interoperability

Measures considered for helping to ensure interoperability in the Delegated Act include:

- Definition of technical C-ITS communication profiles in specifications
- Functional description of Day 1 services in specifications

A project partner felt that there needs to be agreement on the core set of services to focus on across Europe. They did not consider it a problem for a Member State to identify and successfully implement services that were not part of this core set of services, as other Member States would be able to learn from that experience. However, services need to be implemented using the same type of communication across Europe, to ensure consistent messaging across borders, nationalities and operators. The project partner gave an example to illustrate what should not happen: some Member States were saying that road works warnings could be implemented using short-range communication, while other Member States were not readily equipped with this technology yet.

The project partner elaborated on this, stating that the service should work for the user in the same way everywhere. For this to happen, the choice in communication technology was irrelevant, however the situation became more complicated when newly standardised technologies like LTE-V2X would be able to communicate directly in the same 5.9 GHz frequency band as other technologies. This issue is recognised and being dealt with on the CEPT level, by investigating coexistence possibilities.

The options mentioned above were considered to be common outputs of the C-Roads projects by the project partner. They suggested that these elements should be included in the Delegated Act in the specification, or at least as an Annex referred to in the Act.
D.9.4.6. Compliance testing

Measures considered for compliance assessment in the Delegated Act include:

- Definition of common minimum requirements for deployment of Day 1 C-ITS services in specifications
- Definition of compliance assessment process for Day 1 C-ITS services in specifications
- Requirement for any new C-ITS station to fulfil the compliance assessment criteria to be part of the C-ITS security trust model
- Ensure backward compatibility of new services and/or technologies with already deployed services
- Ensure consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.

The need for several actors to be involved in compliance testing has been identified, including those governing the processes and those governing the operations, according to a project partner. However, which actors will fulfil these responsibilities has yet to be identified.

Ensuring backwards compatibility and consistency with other validation frameworks was considered essential by the project partner. Overall, the list of options above was considered suitable.

D.9.4.7. Continuity of services

Measures considered for helping to ensure continuity of services in the Delegated Act include:

- Definition of Day 1 services in specifications
- Functional description of Day 1 services in specifications
- Reference (prioritise) deployment of Day 1 services
- Mandate combined deployment of Day 1 services

Given the profiling of a core set of services being carried out by the C-Roads Platform, a project partner was optimistic about the continuity of services. However, it is worth noting that the countries that had joined the C-Roads Platform more recently often had a broader scope of services, as a result of the further developments in C-ITS that had taken place since the early adopters began their projects. This broader scope is often working towards automation, e.g. in Italy where platooning is included in their set of services.

The definition of Day 1 services should be included in the specifications of the Delegated Act, or included as an Annex with a reference to the results of the C-Roads projects.

D.9.4.8. Coordination

Measures considered for addressing coordination issues in the Delegated Act include:

- Establishment of EU governance bodies (C-ITS governing body, C-ITS supervision body, compliance assessment bodies)
- Establishment of EU policy authorities (privacy policy authority, security policy authority, certificate policy authority)
- Establishment of EU operational bodies (trust list manager, C-ITS point of contact, EU root certification authorities)
A project partner noted that while the deployment framework has been presented in the C-ITS Strategy, as well as by Working Groups and reports from the C-ITS Platform, there is still work to be done in defining the governance required. There has been limited progress in this regard so far from the C-ITS Platform and the C-Roads harmonisation work.

The three options outlined above were broadly agreed on by the project partner. These organisations must have European coverage and comply with EU policy, and are likely to be an EU-level body (although this aspect was not considered to be essential). The project partner noted that the subsidiarity principle needs to be applied so that action at the EU level brings added value.

**D.9.4.9. Enabling environment**

<table>
<thead>
<tr>
<th>Measures considered for addressing enabling environment issues in the Delegated Act include:</th>
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</thead>
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</tr>
<tr>
<td>• Mandate for standardisation organisations</td>
</tr>
</tbody>
</table>

A project partner highlighted the need for practical collaboration. The C-Roads Platform has done some work on identifying business models. They have noticed that it was easier for public authorities to share business cases, whereas private operators were often reluctant to do so. The public sector actors recognise that this is difficult for the private sector to share commercial information, but believe that there is still value in at least understanding the nature of the business opportunities available, without needing to know the details of the respective private sector business models.

The project partner supported all of the options listed above.

**D.9.4.10. Other discussion points**

A project partner noted the need for C-ITS elements to be congruent with developments in autonomous vehicles. They felt that there was already a need for further legal clarity to be put into the Delegated Act, in light of recent developments in this area, which could be amended later, as necessary.

Regarding impacts on SMEs, the project partner noted that there were some smaller partners involved in C-Roads Germany. More generally, he felt that there may be opportunities for SMEs as a result of the fact that having open access to data will lower the costs of developing services based on these.

The project partner also noted that Germany has been a front runner regarding C-ITS. The front runners have taken risks to pilot new technology, and the countries now adopting C-ITS will be able to benefit from this as they can incorporate elements of the C-Roads projects into their deployment. The recent adopters do not have to design their traffic management systems in the same way as the front runners, but instead can apply
the general principles identified in the pilot projects, as well as the specifications and profiles set out in the Delegated Act. In this way, the front runners have the opportunity to be influencers on a European scale.

D.9.4.11. Monitoring and evaluation

A project partner suggested that pilot projects had a self-interest in monitoring and evaluation, as there was no value from either a technical or a procedural point of view when messages were not transmitted properly. The C-Roads pilot projects are also setting up a common evaluation and assessment plan.

Member States already have to supply reports on implementation within the context of the ITS Directive, and they are improving in their ability to report on these topics.
**D.10. CASE STUDY: C-Roads Slovenia**

<table>
<thead>
<tr>
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<td>February 2016</td>
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</tr>
<tr>
<td>Location of pilot(s):</td>
<td>TEN-T highways A1 (section Ljubljana-Koper), A3 (section Divaca-Sezana), and A4 (section Razdrto-Vipava)</td>
</tr>
<tr>
<td>Project scope - Number of vehicles:</td>
<td>The aim is to have three of their own vehicles equipped with C-ITS technology for testing</td>
</tr>
<tr>
<td>Project scope - Length of roads (number of RSUs):</td>
<td>100 km of TEN-T core network</td>
</tr>
<tr>
<td>Services covered:</td>
<td>Traffic jam ahead warning, hazardous location notification, road works warning, weather conditions, in-vehicle signage, in-vehicle speed limits, probe vehicle data</td>
</tr>
</tbody>
</table>

**D.10.1. Introduction**

**D.10.1.1. Background**

The national motorway company, DARS, are coordinating the Slovenian contribution to the C-Roads Platform, which will involve a pilot project taking place on 100 km of the core network in 2019. C-Roads Slovenia\(^{77}\) will pilot Day 1 C-ITS services that use hybrid and both “Infrastructure to Vehicle” (I2V) and “Vehicle to Infrastructure” (V2I) communications will be tested. The delivery of real time traffic information will be delivered through a mobile app.

Slovenia is currently behind other EU Member States in C-ITS research and deployment. Therefore, this project is a key step in advancing the national understanding of the technology; C-Roads Slovenia has been drawing on the experience and knowledge of other projects. The C-Roads Platform has been an invaluable resource for facilitating these flows of information and the project lead noted that they will be keen to share any information and experience they gain over the course of this project.

**D.10.1.2. Objectives**

C-Roads Slovenia has three main objectives:

- Pilot Day 1 C-ITS services using hybrid communication.
- Analyse pilot data to produce solutions for the new C-ITS services, in cooperation with other C-ITS stakeholders to ensure interoperability.
- Upgrade the C-ITS infrastructure on the TEN-T network and integrate into the regional Traffic Management Centre (TMC).

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\(^{76}\) https://www.dars.si/

\(^{77}\) https://www.c-roads.eu/pilots/core-members/slovenia/Partner/project/show/c-roads-slovenia.html
D.10.2.  Progress to date

The project is at an early stage with the implementing body focused on coordinating the development of the project consortium and signing contracts with other stakeholders. DARS is currently the only partner in the project. While there has been a lot of interest, no other partner has yet joined the consortium. An important task is organising the hybrid communication architecture with cellular and ITS-G5 providers. While a contract has been signed with a cellular provider, the project team have encountered issues with the public tender for an ITS-G5 technology provider.

D.10.3.  Barriers and challenges

D.10.3.1.  Security

A project representative commented that security is one of the most open areas for discussion and is a challenge that they face in the project and one that they are still working to overcome. Within C-Roads Slovenia they see the security of data as the principal issue (see below).

D.10.3.2.  Privacy and protection of personal data

As the project team consider privacy and the protection of data the most important security issue, they have focused on attempting to address this rather than the security of the system or the equipment. They would like to include a security expert in the project who will be able to address the security problem for them.

They are cooperating with the State Department and are currently waiting for information on how data security issues might be addressed. Ideally the issue of personal data and privacy should be addressed in the design of the technology, but they are waiting for an opinion from their State Department on this issue.

D.10.3.3.  Communication technologies

The project team has chosen a hybrid communications approach as they observed conflicting opinions within the C-Roads platform on the best technology. A project representative thought it was not important which technology was used, rather that there was interoperability and consistency in the messages received by the user. Therefore, it was suggested that, for now, both technologies must be considered.

D.10.3.4.  Interoperability

Currently, there have been no issues of interoperability in the project.

D.10.3.5.  Compliance testing

Currently, there have been no issues of compliance in the project.

D.10.3.6.  Continuity of services

Currently, there have been no issues of continuity of services in the project.

D.10.3.7.  Coordination

In C-Roads Slovenia, there has been some confusion in their tendering processes. Some companies that have responded to tenders have been unsure whether their technology was suitable for the project. Therefore, there needs to be a clearer definition of the technology, which will make technology and infrastructure implementation easier.

D.10.3.8.  Enabling environment

There are no issues identified in this area and a project representative highlighted the important role that the EU is currently playing.
D.10.4. Views on proposed Delegated Regulation on C-ITS

D.10.4.1. Security

Measures considered for addressing security issues in the Delegated Act include:

- Guidance on Security and Certificate policy
- Definition of Security and Certificate policy in specifications
- Mandate Security and Certificate policy
- Definition of operational functions and governance roles in specifications

As a first step, a project representative thought guidance must be provided but that ultimately a standard (by definition) for security must be developed and harmonised across all countries. This standardisation should be an important feature of the proposed Delegated Act. However, they did not think a mandate would be needed as a definition would be sufficient.

D.10.4.2. Privacy and protection of personal data

Measures considered for addressing privacy and data protection issues in the Delegated Act include:

- Guidance on protection of personal data and privacy policy by design and by default
- Include reference to GDPR and e-privacy in specifications
- Requirement for a Data Protection Impact Assessment (IA) in accordance with the GDPR
- Definition of principles for the practical implementation of the GDPR in C-ITS in specifications
- Mandate privacy policy in specifications
- Mandate privacy IA on C-ITS data controller (art. 35 GDPR)

No views were expressed by the project representatives.

D.10.4.3. Communication

Measures considered for ensuring communication compatibility in the Delegated Act include:

- Technology neutrality of spectrum use
- Reference technical standards
- Embed principles of Annex II of ITS Directive (e.g. interoperability, backward compatibility)
- Mandate technical standards
- Functional description of Hybrid Communication in specifications
- Mandate mature communication technologies (with exception for pilot technologies, cf. EETS Directive)

In C-Roads Slovenia, the option of a functional specification of communication technologies would be premature.
D.10.4.4. **Interoperability**

Measures considered for helping to ensure interoperability in the Delegated Act include:

- Definition of technical C-ITS communication profiles in specifications
- Functional description of Day 1 services in specifications

The project representative thought there must be a definition for interoperability, which could be included in the Delegated Act and which should cover all the technical and the functional elements of C-ITS. The functional parts would include the messages that are sent to the user in each country. For example, a German driver coming to Slovenia must get the same messages as they would in Germany.

D.10.4.5. **Compliance testing**

Measures considered for compliance assessment in the Delegated Act include:

- Definition of common minimum requirements for deployment of Day 1 C-ITS services in specifications
- Definition of compliance assessment process for Day 1 C-ITS services in specifications
- Requirement for any new C-ITS station to fulfil the compliance assessment criteria to be part of the C-ITS security trust model
- Ensure backward compatibility of new services and/or technologies with already deployed services
- Ensure consistency with other validation frameworks having an impact on connected and automated vehicles and road infrastructure, e.g. in the future, evolution of data quality requirements may be needed for higher levels of automated vehicles.

There have been talks within the C-Roads Platform about compliance assessment and it is likely that a common compliance assessment framework will be developed. A project representative sees C-Roads as the beginning of a wider deployment platform across the EU, but thinks it is difficult at the moment to see how compliance assessment at this wider level will eventually work.

D.10.4.6. **Continuity of services**

Measures considered for helping to ensure continuity of services in the Delegated Act include:

- Definition of Day 1 services in specifications
- Functional description of Day 1 services in specifications
- Reference (prioritise) deployment of Day 1 services
- Mandate combined deployment of Day 1 services

At an EU level, there must be a platform that will provide common definitions and guidelines ensuring a harmonised approach in each country.
D.10.4.7. **Coordination**

Measures considered for addressing coordination issues in the Delegated Act include:

- Establishment of EU governance bodies (C-ITS governing body, C-ITS supervision body, compliance assessment bodies)
- Establishment of EU policy authorities (privacy policy authority, security policy authority, certificate policy authority)
- Establishment of EU operational bodies (trust list manager, C-ITS point of contact, EU root certification authorities)

A common platform would also be important regarding coordination. However, it was noted that it is too early for the establishment of the EU bodies suggested in the options above.

D.10.4.8. **Enabling environment**

Measures considered for addressing enabling environment issues in the Delegated Act include:

- Policy advice through stakeholder platform
- Programme support action (PSA) under the Connecting Europe Facility (CEF) for the set-up of common EU elements
- Requirements for the exchange of best practice
- Memorandum of Understanding (MoU) in a ‘bottom-up’ approach in which stakeholders could drive activities and initiatives
- Funding for deployment projects
- Funding / coordination of research
- EU deployment coordination
- An agreement on access to selected, specified data for C-ITS services between all relevant public and private stakeholders
- Mandate for standardisation organisations

No views were expressed by the project representatives.

D.10.4.9. **Other discussion points**

They have found it difficult to bring partners on board. There has been interest in being involved with the project but not as a partner.

To date, the response to their tenders has been from large companies rather than SMEs.

The C-Roads Slovenia project has the potential to act as an example to other countries that are just starting to begin deployment of C-ITS services.

D.10.4.10. **Monitoring and evaluation**

It has been important for Slovenia to gather information from more experienced countries and while this should continue, it is too early to formalise this information gathering process.
D.11. CASE STUDY: United States

D.11.1. Overview and Key Messages

The U.S. C-ITS policy approach centres around U.S. Department of Transportation (DOT)-led deployment pilot projects. These pilot projects demonstrate the benefits of C-ITS services, and result in states and local authorities independently pursuing deployment with some Federal aid. The ITS Joint Programme Office (ITS JPO) within the U.S. DOT provide 5-year strategic plans which guide the direction of ITS research and deployment in the U.S. The ITS JPO are also responsible for coordinating and sharing research findings nationally and internationally.

The U.S. have been pursuing a mandate to install V2V DSRC communications technology in all new light duty vehicles.

There are three major Connected Vehicle (CV) Pilot projects taking place in the U.S. in New York City (New York), Tampa (Florida), and the I-80 corridor in Wyoming. Across the three, a wide range of C-ITS applications are being tested, with the results being shared nationally to encourage further C-ITS deployment. Another key pilot project is taking place in Ann Arbor, Michigan (with the support of the University of Michigan), looking at safety-critical C-ITS applications. The Spat Challenge encourages state and local public sector transportation infrastructure owners to deploy DSRC infrastructure in at least one corridor or network of approximately 20 signalised intersections in each state by January 2020, while ensuring deployments are compatible and meet the minimum requirements to support on-board applications released by vehicle manufacturers.

The U.S. appears to be at a similar stage to the EU in developing C-ITS services, focusing on defining standards to ensure various issues (such as privacy and data protection, interoperability and harmonisation) are met. Localised deployment projects are becoming more common, but are not yet widespread or deployed over significant geographical areas.

D.11.2. Policy Overview

The U.S. DOT’s present approach to C-ITS policymaking has been informed by its historical experience with ITS research as well as by consultation with stakeholders. As with all ITS technologies, the policy approach focuses on early U.S. DOT-led deployment pilot projects which provide examples for states and local authorities to deploy C-ITS services independently with the use of Federal aid funding. This approach relies on the technology having proven benefits which can be shown through U.S. DOT pilot projects. A government stakeholder indicated that this approach has been successful, as deployment by regional authorities is starting to happen.

D.11.2.1. Mandating V2V communication

The National Highway Traffic Safety Administration (NHTSA) submitted a Notice of Proposed Rulemaking (NPRM) in December 2016 to create a new Federal Motor Vehicle Safety Standard to require V2V communication capability for new light duty vehicles. This decision was the culmination of several years of work, and involved taking the following considerations into account: estimates of the ability of V2V technology to reduce crashes and fatalities; technology maturity, cost, reliability, and performance; and the availability of means for measuring the performance of V2V technology in an objective way. NHTSA states that it believes no single manufacturer would have the incentive to build V2V-capable vehicles unilaterally, and used this argument to justify its decision to impose obligatory standards. NHTSA included in its proposed rule technical standards for how V2V communications should be performed, which draws on the standards that are already under development by industry and the Standards Developing Organisations with support from U.S. DOT programmes (U.S. DOT, 2014b).

In November 2017, the Trump administration announced that they would no longer be pursuing a mandate for DSRC V2V communications technology (Lowy, 2017).
decision was justified by a reluctance to impose costly mandates on industry, despite most automakers supporting the mandate. The U.S DOT and the NHTSA have stated that they are still reviewing comments on the proposed mandate and no final decision has been made (NHTSA, 2017).

D.11.2.2. **Rationale for the government’s focus on safety and V2V**

Safety benefits are the key drivers for implementing V2V technologies in the US. Other benefits that support regulation of V2V and V2I systems include: reduced congestion, improved efficiency (reduced fuel usage), improved freight movement, and reduced environmental impacts (e.g. emissions). U.S. DOT’s efforts related to these technologies are being led by NHTSA and the Intelligent Transportation Systems (ITS) Joint Program Office within U.S. DOT’s Research and Innovative Technology Administration (RITA). The focus will be crash avoidance technologies. U.S. DOT will also work with the Federal Communications Commission (FCC) to determine whether the 5.9 GHz spectrum reserved for V2V communications can be “shared” with unlicensed users. The Department has committed to completing a preliminary test plan within 12 months after industry makes production-ready devices available for testing.

One very significant test of safety-critical V2V communication systems was The Safety Pilot Model Deployment, which launched in August 2012, and was originally budgeted at €25m (80 percent of which was provided by the U.S. DOT) (U.S. DOT, 2014d). This was a first-of-its kind pilot project to assess the potential safety benefits of the technology in real-world settings, and involved nearly 3,000 V2V-equipped vehicles for the everyday travel of individuals. Applications warned of vehicles ahead, vehicles in blind spots, and of impending red-light violations, and communicated using the standards that were under development by the US Standards Developing Organisations. Interoperability of different devices (e.g. retrofitted ITS stations and purpose-built V2V enabled vehicles) was achieved, and the pilot was regarded as a successful demonstration of the potential safety benefits of the technology (U.S. DOT, 2015b).

Another key benefit is that a focus on V2V communications helps provide interoperable services. There are relevant standards for V2V which have been developed by the IEEE and the Society of Automotive Engineers (SAE).

A government stakeholder indicated that there is not yet an answer on whether the 5.9 GHz spectrum can be shared. The U.S. DOT have been working with the FCC to conduct tests with devices that the manufacturers state can share the bandwidth. The FCC announced a three-phase test plan in June 2016 (Federal Communications Commission, 2016). LTE C2X interference with DSRC was tested in San Diego in December 2017, however the results are not yet announced.

The proposed regulation will address two key components of the crash avoidance systems: 1) V2V regulation (NHTSA); and 2) infrastructure V2I and I2V (NHSTA and Federal Highway Administration-FHWA). Radio specifications and safety methods (e.g. intersection movement assist, left turn assist) have already been defined. At this time, no legislation beyond that described in the ANPRM is anticipated.

D.11.2.3. **Standards for C-ITS**

Compared to the EU standards for C-ITS, the US has adopted a smaller number of C-ITS standards, describing technology that is generally simpler and focussed on safety-critical applications (Austroads, 2015). The relevant standards developing organisations in the US are SAE International, the IEEE (Institute of Electrical and Electronics Engineers), and the Joint Committee on the NTCIP (National Transportation Communications for ITS Protocol). A 2015 review by Austroads identified that these organisations had developed a set of 11 standards associated with deployment of safety-critical dedicated short-range communications (DSRC) C-ITS applications (compared with the EU’s 157 C-ITS standards). U.S. DOT policy is to continue to support the development of C-ITS standards and update these in light of field testing and technological developments, but also to harmonise US standards with those used by the...
EU and other regions where appropriate. A Harmonisation Action Plan was agreed with the EU in 2011. An illustration of the sets of standards in use in the US versus the EU is shown in Figure D-1.

**Figure D-1: Sets of C-ITS standards in the US versus EU**

![Diagram showing sets of C-ITS standards in the US versus EU]

*Source: (Austroads, 2015)*

### D.11.2.4. Grants for infrastructure (and infrastructure strategy in general)

Initial demonstrations and pilots are and will continue to be funded by U.S. DOT; full scale implementation of V2V and V2I systems is to be jointly supported using Federal Highway Administration (FHWA) funds distributed to the states. NHTSA’s FY 2015 Budget was $851 million and included $152 million for Vehicle Safety, $122 million for Behavioural Safety and $577 million for State Grants and High Visibility Enforcement Support. C-ITS and V2V research is categorized under Forward Collision Avoidance and Mitigation (FCAM). Research funds for FCAM originate within the Vehicle Safety Program administered by NHTSA ($38 million to vehicle safety research and analysis, of which $8 million will go to crash avoidance research) and Highway Traffic Safety Grants administered by the states (NHTSA, 2015). It was projected that crash avoidance research was to be funded at this level into 2017. In addition, states have the option to apply FHWA funds to V2V and V2I deployment. The FHWA Budget (Moving Ahead for Progress in the 21st Century – MAP 21) included $100 million/year up to 2017 for Intelligent Transportation Systems Programs, an additional $72 million per year for university transportation centres, and $115 million for highway research and development programs. States may also solicit funds for Transportation Infrastructure Finance and Innovation Programs ($1 billion/year). Federal Highway Program Apportionments to the states for 2015 included $2.2 billion for the Highway Safety Improvement Program and $2.3 billion for the Congestion Mitigation & Air Quality Improvement Program, both of which could have been used to support C-ITS deployments.

Another source of funding for C-ITS technologies is the $60 million a year Congestion Management Technologies Deployment (ATCMTD) Project Awards programme. This
programme is mandated as part of the Fixing America’s Surface Transportation (FAST) Act and provides up to 50 percent of project costs (U.S. DOT, 2016). Each year the U.S. DOT selects a number of sites for this funding\(^7\), which shows a move from U.S. DOT-run programmes toward states developing their own deployment models with U.S. DOT funding.

### D.11.2.5. Industry strategy

Industry equipment and service providers anticipate a wider market within ITS, including integration with automotive and infotainment telematics, freight and commercial applications, ITS communications (both DSRC and cellular/satellite based systems), network management, public transportation, road safety, and security/crime reduction. Moving from vehicle-based systems to wider areas of communications (e.g. portable systems) presents challenges and opportunities. One telecommunications company representative indicated that over the air (OTA) services, such as those employed by Tesla for system updates, will drive connectivity via cellular networks. Using OTA for updates and to address electronic system recalls has the potential to reduce OEM costs by $100/vehicle/recall.

One industry spokesman suggested state and local agencies as well as NGOs should become involved in preparing the public for the introduction of C-ITS technologies. It was stated “This is a consumer product, not a vehicle product”. Many stakeholders are participating in the University of Michigan’s Mobility Transformation Center (MTC) located in Ann Arbor, Michigan (see http://www.mtc.umich.edu/vision). Participants include government (U.S. DOT, Michigan DOT (MDOT), the City of Ann Arbor), industry (vehicle manufacturers, telecommunications suppliers, traffic control systems suppliers, insurance companies, public transportation system stakeholders, payment system suppliers, and smart parking companies), and university researchers (Texas A&M, University of Michigan). MDOT is supporting development of the Southeast Michigan connected corridor, which includes 125 miles of expressways (US23, I696, I94, and I75). Roadside infrastructure is being installed that will support over 20,000 connected vehicles plus 2,000 connected and automated vehicles.

Application radio developers are working on a wide range of products. It is expected that these will initially be extensions of existing traffic alert products, such as WAZE. WAZE is based on information provided by logged-in members and is related to Google Maps to determine the number of vehicles per section of road and how rapidly their locations are changing. Tying this into retrofitted DSRC equipment would improve the accuracy of the system and would provide a platform for safety-related applications. Other possibilities include parking space locators and notice of pedestrians crossing roads. These are all consumer-facing applications which reinforce the need to support consumer acceptance and adoption.

A Government stakeholder noted that there is currently movement by the cellular industry to deploy C2X as a replacement for DSRC. There have been recent studies into this possibility, with the applications, security and architecture remaining the same. One issue with this is that the two technologies are not interoperable, and so would currently require two radios in the vehicle unless everyone commits to this change.

### D.11.2.6. Retrofits of existing fleet

The U.S. DOT sees an opportunity to accelerate the applications and benefits through retrofit programs. Aftermarket applications were included in the Safety Pilot program. Industry representatives have indicated that the turnover of existing vehicles will limit adoption of C-ITS. Their suggested solution was to develop cost effective retrofit systems. Making the systems consumer-based (enhanced features) would accelerate deployment. One drawback of retrofit systems is that they might not be fully integrated

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with the vehicle electronics (limited access to sensor data such as brake status) and the DSRC network, which could compromise the robustness of the data sent to other vehicles with a resulting impact on the preciseness of the warning messages. Thus, technical standards are required for these devices to ensure interoperability and effectiveness.

D.11.3. Research programmes

D.11.3.1. Development of U.S. DOT’s strategic plans

The 2005-2009 ITS research program included nine research initiatives focused on departmental goals for safety, reduced congestion and global connectivity. The research program culminated in the development of new, prototype, short-range wireless technologies and applications for safety that were successfully demonstrated in a highly mobile environment.

Based on these results, a connected transportation environment was envisioned through V2V and V2I communications and applications which became the core of the ITS Strategic Research Plan, 2010-2014. With the rapid evolution of commercial wireless technology, the U.S. DOT’s vision evolved to incorporate an inclusive concept of connected vehicles and infrastructure using both DSRC and other mobile data communications technologies. The plan was designed to achieve a vision of a national, multi-modal surface transportation system that featured a connected transportation environment among vehicles, infrastructure and passengers’ portable devices to maximise safety, mobility and environmental performance.

The current research program is described in the ITS Strategic Research Plan, 2015-2019 (U.S. DOT, 2015a), which focuses on V2V and V2I connectivity through wireless technologies. One of the key priorities in the Plan is to realise connected vehicle implementation, building on the progress made in recent years around design, testing and planning for the deployment of connected vehicles in the USA. Within this priority, there are five strategic themes set out in the plan.

These are:

- Enabling safer vehicles and roadways by developing a range of C-ITS services.
- Enhancing mobility by exploring strategies to increase system efficiency.
- Limiting environment impacts by improving on-road conditions (traffic flow, congestion, speed) using technology.
- Promoting innovation by aligning future transportation needs with technological research and development, and innovation
- Supporting transport system information sharing by developing standards and architectures, and communication technologies for V2V and V2I.

Realisation of C-ITS is intended to contribute to each of these objectives, although there is presently a clear emphasis on early action on safety. The U.S. DOT’s C-ITS activities are currently more focussed on adoption and deployment rather than research and testing, although the Department plans to continue investigating new technology and new functionality as it emerges, especially in response to issues arising from deployment projects (U.S. DOT, 2014a).

The U.S. DOT’s programmes of support for research, development, and adoption of C-ITS can be divided into two categories; support for V2V communications based on DSRC technology, and other C-ITS technologies and communications that may be enabled either by DSRC or by other networks such as cellular.

ITS JPO provide cross-cutting support for all C-ITS research and deployment in the United States. The National ITS Architecture (DOT, 2018) provides a common framework for planning, defining and integrating C-ITS, that covers contributions from a range of stakeholders who may be involved. ITS JPO also run an ITS Professional
Capacity Building (PCB) programme which aims to develop an ITS workforce through a range of learning opportunities.

**D.11.3.2. Stakeholders involved**

The ITS Strategic Plan was developed with significant stakeholder input, both within the U.S. DOT and externally, including industry groups, state and local government, academics, and vehicle manufacturers. The stakeholders provided “technical, organisational, contextual, and policy needs specific to their environments”. All stakeholders indicated that they were happy with the current level of emphasis on C-ITS research, and most of them indicated that they would be receptive to the Department’s plans to accelerate deployment of this technology, although a significant majority also expected that new capabilities not currently associated with “connected vehicles” will also ultimately impact on the C-ITS environment (U.S. DOT, 2015a).

From time to time the U.S DOT has sought to involve various sub-sets of these stakeholders in its decision-making processes or to encourage them to form their own partnerships.

- The Department consulted vehicle manufacturers, state and local governments, representative associations, citizens, and others to identify policy and institutional issues that might hinder the successful deployment of new and emerging C-ITS technologies (U.S. DOT, 2015d).
- The Department supports the development and maintenance of standards promoted by SAE and IEEE (U.S. DOT, 2015e).
- The Department’s Safety Pilot Model Deployment project was run by the University of Michigan, working in partnership with a consortium of nine OEMs called CAMP (Crash Avoidance Metrics Partnership, whose members include vehicle manufacturers such as GM and Ford); volunteer drivers; a transit agency; and commercial vehicle operators.
- For the next wave of C-ITS pilot projects, the Department wants to encourage partnerships between state governments, transit agencies, commercial vehicle operators and other private companies (U.S. DOT, 2017).
- To create a secure DSRC V2V communication system for safety-critical applications, the Department believes it will be necessary to find an entity – possibly a private company – that would be willing to manage a security and communications sub-system (U.S. DOT, 2014c).

**D.11.4. Targeted C-ITS applications**

**D.11.4.1. Characteristics**

In terms of regulatory action, the U.S. DOT has indicated that it is focussed on enabling safety-critical applications through V2V technology. The NHTSA’s notice of proposed rulemaking (NPRM) emphasised the potential for V2V to improve safety by preventing a large proportion of unimpaired crashes. It also described V2V as a “gateway” to V2I technology that would rely on the same DSRC capability.

The U.S. DOT is focussed on DSRC technology. DSRC is an obligatory component of any pilot sponsored as part of the CV Pilots Deployment Project. The NHTSA’s research paper (NHTSA, 2014) accompanying its Advance Notice of proposed rulemaking assessed various alternative technologies and reached the preliminary conclusion that DSRC was the most appropriate one due to its readiness for deployment, but it also invited stakeholders to submit evidence in the next stage of the consultation that other technologies might provide V2V safety applications in an optimal way.
D.11.4.2. Specific applications

The NHTSA stated in its research report that it was investigating six safety applications that could be enabled by DSRC: Intersection Movement Assist (IMA), Forward Collision Warning (FCW), Do Not Pass Warning (DNPW), Emergency Electronic Brake Lights (EEBL), Blind Spot Warning / Lane Change Warning (BSW/LCW), and Left Turn Assist (LTA). The ITS Joint Program Office has described concepts of operations for a large set of applications (i.e. a set that includes many applications not primarily related to safety) which it may consider funding as part of the Connected Vehicles Pilots Deployment Project. These are listed in Figure D-2. The pilot may also fund deployment of other applications, not listed in Figure D-2, if these are put forward by winning bidders.

Figure D-2: Applications with potential for inclusion in the CV Pilots Deployment Project

<table>
<thead>
<tr>
<th>V2I Safety</th>
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<tbody>
<tr>
<td>Red Light Violation Warning</td>
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<tr>
<td>Curve Speed Warning</td>
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<tr>
<td>Stop Sign Gap Assist</td>
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<tr>
<td>Spot Weather Impact Warning</td>
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<tr>
<td>Reduced Speed/Work Zone Warning</td>
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<td>Pedestrian in Signalized Crosswalk Warning (Transit)</td>
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<table>
<thead>
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<th>V2V Safety</th>
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<tr>
<td>Emergency Electronic Brake Lights (EEBL)</td>
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<tr>
<td>Forward Collision Warning (FCW)</td>
</tr>
<tr>
<td>Intersection Movement Assist (IMA)</td>
</tr>
<tr>
<td>Left Turn Assist (LTA)</td>
</tr>
<tr>
<td>Blind Spot/Lane Change Warning (BSW/LCW)</td>
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<tr>
<td>Do Not Pass Warning (DNPW)</td>
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<tr>
<td>Vehicle Turning Right in Front of Bus Warning (Transit)</td>
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<tr>
<th>Agency Data</th>
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<tbody>
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<td>Probe-based Pavement Maintenance</td>
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<td>Probe-enabled Traffic Monitoring</td>
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<td>Vehicle Classification-based Traffic Studies</td>
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<td>CV-enabled Turning Movement &amp; Intersection Analysis</td>
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<td>CV-enabled Origin-Destination Studies</td>
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<tr>
<td>Eco-Approach and Departure at Signalized Intersections</td>
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<td>Eco-Traffic Signal Timing</td>
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<td>Eco-Traffic Signal Priority</td>
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</tr>
<tr>
<td>Eco-Ramp Metering</td>
</tr>
<tr>
<td>Low Emissions Zone Management</td>
</tr>
<tr>
<td>AVF Charging / Fueling Information</td>
</tr>
<tr>
<td>Eco-Smart Parking</td>
</tr>
<tr>
<td>Dynamic Eco-Routing (light vehicle, transit, freight)</td>
</tr>
<tr>
<td>EcoJCM Decision Support System</td>
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<table>
<thead>
<tr>
<th>Mobility</th>
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<tbody>
<tr>
<td>Advanced Traveler Information System</td>
</tr>
<tr>
<td>Intelligent Traffic Signal System (I-TSIG)</td>
</tr>
<tr>
<td>Signal Priority (transit, freight)</td>
</tr>
<tr>
<td>Mobile Accessible Pedestrian Signal System (PED-SIG)</td>
</tr>
<tr>
<td>Emergency Vehicle Preemption (PREEMPT)</td>
</tr>
<tr>
<td>Dynamic Speed Harmonization (SPDHARM)</td>
</tr>
<tr>
<td>Queue Warning (Q-WARN)</td>
</tr>
<tr>
<td>Cooperative Adaptive Cruise Control (CACC)</td>
</tr>
<tr>
<td>Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STDG)</td>
</tr>
<tr>
<td>Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)</td>
</tr>
<tr>
<td>Emergency Communications and Evacuation (EVAC)</td>
</tr>
<tr>
<td>Connection Protection (T-CONNECT)</td>
</tr>
<tr>
<td>Dynamic Transit Operations (T-DISP)</td>
</tr>
<tr>
<td>Dynamic Ridesharing (D-RIDE)</td>
</tr>
<tr>
<td>Freight Specific Dynamic Travel Planning and Performance Drayage Optimization</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Road Weather</th>
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<tbody>
<tr>
<td>Motorist Advisories and Warnings (MAW)</td>
</tr>
<tr>
<td>Enhanced MDSS</td>
</tr>
<tr>
<td>Vehicle Data Translator (VDT)</td>
</tr>
<tr>
<td>Weather Response Traffic Information (WxTINFO)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Smart Roadside</th>
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<tbody>
<tr>
<td>Wireless Inspection</td>
</tr>
<tr>
<td>Smart Truck Parking</td>
</tr>
</tbody>
</table>

Source: (U.S. DOT, 2017)

With the commencement of Phase 2, Design/Build/Test of the Connected Vehicle Pilot Deployment programme (see Section D.11.5.1), in September 2016, the three sites (New York City, Tampa, FL, and Wyoming) have announced their planned C-ITS services. Each pilot chose to focus on providing C-ITS services that meet the needs of the location. Therefore, the pilots vary in size and the C-ITS services employed, shown in Table D-1.
Table D-1: C-ITS services deployed in the C-ITS Pilot Deployment programme by site

<table>
<thead>
<tr>
<th>Category</th>
<th>C-ITS service</th>
<th>NYC</th>
<th>Tampa</th>
<th>Wyoming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Speed compliance</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Curve speed compliance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Speed compliance/work zone</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Red light compliance/warning</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oversize vehicle compliance</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emergency communications</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>End of ramp deceleration</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V2I/I2V Safety</td>
<td>Wrong way entry</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I2V situational awareness</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Spot weather impact warning</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Forward collision warning</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Emergency electronic brake lights (EEBL)</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blind spot warning (BSW)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lane change warning/assist (LCA)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intersection movement assist (IMA)</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vehicle turning right in front of bus warning</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distress notification</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>V2V Safety</td>
<td>D.11.5. Deployment and results</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D.11.5.1. CV Pilots Deployment Project</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The U.S. DOT’s Connected Vehicle Pilot Deployment Program (U.S. DOT, 2017) aims to encourage early adoption of C-ITS services through a number of pilot programmes. The pilots are expected to implement connected vehicle research concepts into practical and working services that enhance operational capabilities, and focus on enabling safety-critical C-ITS applications.</td>
<td></td>
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</tr>
</tbody>
</table>
The pilots also aim to encourage multi-stakeholder partnerships across a range of stakeholders, including private companies, states, transit agencies, commercial vehicle operators, freight shippers, etc. The deployment aims to cover all elements of surface transport and to improve system performance and management. The pilots will also support impact assessment and evaluation efforts that will help to inform wider cost-benefit analyses of C-ITS services.

There are three initial programme goals (U.S. DOT, 2017). First, to encourage technological development in connected vehicles including mobile devices, infrastructure, traffic management centres and other elements. Second, to improve and measure safety, mobility and environmental impacts. The data acquired will be from real world impacts and benefits, which must be differentiated and identified as coming from specific C-ITS services. Finally, to problem solve deployment issues such as institutional and financial arrangements necessary to successfully manage and govern a sustainable C-ITS programme.

**D.11.5.2. Timings of C-ITS Pilot Deployment Program**

The U.S. DOT's timetable for the C-ITS Pilots Deployment Program is set out in Table D-2. The U.S. DOT issued a solicitation in January 2015 to invite bids for the concept development phase of the first wave of pilots. In September 2015, the U.S. DOT announced that New York City, Wyoming, and Tampa, FL, would receive a combined total of $42m for Phase 1 deployment, with a further $54m announced in September 2016 to initiate Phase 2.

**Table D-2: Timing of U.S. DOT's C-ITS Pilots Deployment Program**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activity</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Pre-deployment</td>
<td>Jan 2015 to Sept 2015</td>
</tr>
<tr>
<td>1</td>
<td>Concept development</td>
<td>Sept 2015 to Sept 2016</td>
</tr>
<tr>
<td>2</td>
<td>Design, build and test pilot</td>
<td>Up to 20 months (Sept 2016 to May 2018)</td>
</tr>
<tr>
<td>3</td>
<td>Maintain and operate pilot</td>
<td>Up to 18 months (May 2018 to September 2021)</td>
</tr>
</tbody>
</table>

**D.11.5.3. The SPaT Challenge**

The SPaT Challenge (NOCoE, ND) aims to encourage state and local public-sector transportation infrastructure owners to deploy DSRC infrastructure in at least one corridor or network of approximately 20 signalised intersections in each state by January 2020. A key part of this challenge is the SPaT Challenge Verification Document which provides guidance for deployments to ensure that they are compatible and meet the minimum requirements to support on-board applications released by vehicle manufacturers. The focus is on compatibility with Red Light Violation Warning applications.

SPaT deployment is operational in 8 states already, with many more deployments underway.

**D.11.5.4. Impacts, evaluation and lessons learnt**

C-ITS projects can be evaluated using the ITS Evaluation (US DOT, ND) programme which provides a common framework for understanding and evaluating the value, effectiveness and impact of projects in the National ITS programme. The evaluation covers activities in six tracks that allow for the continuous refinement of the C-ITS deployment programme. These tracks are: ITS research evaluation, ITS deployment tracking surveys, ITS deployment evaluation, ITS programme evaluation, knowledge...
management, and knowledge transfer. This process not only assists with the evaluation of the project itself, but encourages the sharing of project knowledge with others to help coordinate deployment at a national level.

The knowledge sharing activities described above are managed through a web-based database known as the ITS Knowledge Resources (US DOT, 2018). The database contains over eighteen years of summaries on the benefits, costs and lessons learnt from ITS implementations, including ITS evaluation studies, research syntheses, handbooks, journal articles and conference papers. Most recently, the ITS JPO has released the Intelligent Transport Systems Benefits, Costs and Lessons Learned: 2017 Update Report (U.S. DOT, 2017). The report summarises the evaluation highlights for each of the application areas covered. The Knowledge Resources and the report aim to provide easily accessible best practice information for a wide range of users who might be involved in C-ITS deployment. The lessons learnt focus on reflecting on what was done right, what could be done differently, and how interventions could be more effective in the future.

D.11.5.5. **Expected impacts of C-ITS in general**

The U.S. DOT’s Strategic Plan identifies a number of potential benefits arising from its C-ITS programme, listed in Table D-3.

<table>
<thead>
<tr>
<th>Table D-3: Potential benefits of U.S. DOT’s C-ITS programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases in safety, mobility, system efficiency, and access to resources for disadvantaged groups, and decreases in negative environmental impacts such as vehicle emissions, the need for physical expansion, and noise</td>
</tr>
<tr>
<td>Decreases in undesirable transportation impacts to the environment and society</td>
</tr>
<tr>
<td>Increased opportunities to partner with non-government groups, such as private industry and universities</td>
</tr>
<tr>
<td>Real-time and real-world data to help with transportation planning and transportation system operations</td>
</tr>
<tr>
<td>Demonstrations of CV environments that fit into real-world environments of today</td>
</tr>
<tr>
<td>Reduction of fatalities through weather-related, safety, infrastructure-based, and other applications</td>
</tr>
</tbody>
</table>

Source: (U.S. DOT, 2014a)

The U.S. DOT states that V2V and V2I technology is expected to reduce unimpaired vehicle crashes by 80 percent (U.S. DOT, 2015b). Some specific applications of C-ITS have been given a preliminary cost-benefit assessment by the NHTSA. Some other potential benefits of C-ITS are yet to be quantified; one of the strategic goals of the U.S. DOT is to “develop comprehensive cost-benefit analytic tools that allow deployers to understand the financial and operational benefits of new technologies and systems” (U.S. DOT, 2014a).

To support costing of C-ITS pilots, U.S. DOT sponsored a project called CO-PILOT whose outputs include a tool for estimating at a high-level the likely costs of a C-ITS pilot project.

Industry studies have identified consumer acceptance as a key driver for the adoption of C-ITS. One of the most frequently expressed consumer complaints is a loss of ability to “go my own speed and change lanes when I want to”. Again, consumer education regarding reduced congestion (shorter trip times), reduced fuel use, and improved safety, while offering ancillary benefits (integration with infotainment systems), is necessary to accelerate adoption. There has also been some concern among technology developers that the GPS systems used to determine relative vehicle positions may not be accurate enough; more research is needed in this area and U.S. DOT is currently sponsoring several investigations.
A government stakeholder felt that the CV pilot projects will end up showing significant benefits and positive impacts to the transport system, but these have not yet been fully deployed and evaluated. Once a positive benefit to cost has been shown, states and local authorities will want to deploy C-ITS services.

**D.11.5.6. Expected impacts of NHTSA mandating DSRC V2V communication**

**Expected Costs:**

The NHTSA estimates that V2V equipment and supporting communications functions – including security management – would cost approximately $341 to $350 (€300 to €310) per vehicle in 2020, falling to $209 to $227 (€190 to €200) by 2050 if the industry finds efficiencies in the manufacturing of the technology. It is projected that the costs of roadside equipment will be in the range of $25,000 to $35,000 per installation. One OEM representative estimated a price increase of $30-$40 to include V2V to their vehicles, but this will be dependent on specific OEM electronic architectures.

**Expected Benefits:**

The NHTSA has estimated the benefits of two specific applications, Effectiveness of Intersection Movement Assist (IMA) and Left Turn Assist (LTA), in a scenario in which V2V technology had spread through the entire fleet. The NHTSA estimated that these applications would prevent 25,000 to 592,000 crashes per year, save 49 to 1,083 lives, prevent 11,000 to 270,000 non-fatal injuries, and prevent 31,000 to 728,000 property-damage-only crashes.

Additional DSRC V2V applications would bring additional benefits, with minimal additional costs, as the only additional costs would be attributable to new software.

**D.11.5.7. Barriers and challenges**

The following barriers and challenges were identified during stakeholder engagement with a U.S. DOT representative.

**Barriers to mass deployment of V2V systems**

According to the U.S. DOT, the key barrier to the deployment of C-ITS is the availability of funding. State participation in the deployment programs will be hampered if a long-term funding bill was not passed by Congress.

U.S. DOT is also addressing privacy and security concerns related to C-ITS (e.g. transmission, collection, storage, and sharing of V2V data). Effective approaches related to privacy issues have been developed and must now be tested and verified. Individual protections offered by the EU and the US tend to differ; the extent to which their approaches will converge is an open question (Singer, 2013). U.S. DOT researchers are currently addressing security credential management systems. This includes misbehaviour detection and revocation lists (required if a trusted partner leaves). Key security issues have been identified. On the topic of security credentials, U.S. DOT is working with the automotive industry through the CAMP Vehicle Safety Communications (VSC 3) Consortium to demonstrate and test initial designs. This includes several approaches to implementing security certificates for both infrastructure and vehicle applications.

Issues related to negative public perceptions of C-ITS can be addressed by educational campaigns. One industry spokesman noted the key stakeholders of C-ITS are the end users. Thus, educating consumers regarding these systems was important and must include assurance regarding robustness and ease of use, safety benefits, and privacy: “The biggest gap is public perception and education”. A U.S. DOT spokesman suggested starting with safety-critical, limited scope systems, such as snow removal equipment and police vehicles to demonstrate the value of these systems to both state DOTs and consumers.
Opposition to DSRC has been expressed by various other users of the electromagnetic spectrum. Cellular-based systems have emerged as a potential communications alternative. Another potential barrier is the size of the required V2V communications system. Establishing an effective development plan will pose challenges similar to those encountered with the deployment of current cellular networks. Equipment suppliers indicate that DSRC will be adequate for initial applications and can be readily integrated with other communication systems. A study conducted by the U.S. DOT Volpe National Transportation Systems Center concluded that the life cycle cost per vehicle for DSRC is up to 3.5 times less than leased cellular and satellite-based systems.

There was a concern that initially there would not be enough vehicles on the road with V2V capability for there to be any benefit. An industry spokesman estimated that if only one major OEM offered V2V systems, it might take over two years before there were enough equipped vehicles to provide any benefit. If V2V was mandated however, it might take only one year. Hence OEMs were in favour of the NHSTA V2V mandate.

Liability is not a key issue for current systems and the systems to be deployed in the near future since they are primarily informational (e.g. knowledge of traffic conditions). The U.S. DOT-sponsored Safety Pilot Model Deployment (in which U.S. DOT has partnered with the CAMP VSC 3 Consortium) was conducted by the University of Michigan Transportation Research Institute, UMTRE, and took place in Ann Arbor, Michigan, from August 2012 to February 2014. No liability issues were identified during the Pilot Deployment. However, when DSRC is employed for mobility applications (e.g. platooning, blind spot detection, left turn assist), liability can become a key issue for manufacturers, including system failures and cyber crime. U.S. DOT is evaluating various approaches to system ownership and operation, including Federally-owned, joint public-private ownership, and fully-private ownership as well as operation and liability issues associated with each.

Security

A government stakeholder raised two key aspects when considering security. First, there needs to be a trust management system, such as the security credentials management system described below, which verifies that the message received is from a trusted source. Second, there needs to be protection against external threats, as the DSRC technology could potentially provide another access point to the vehicle. The trust management system does not prevent such threats, so a number of activities are being pursued to secure the connection to DSRC.

One method of preventing external threats is the use of a verified C-ITS message parser (NHTSA, 2016). The cyber security industry has developed a reference parser which can be used to analyse incoming messages through DSRC. Only messages that comply with the reference parser can be used. The reference parser would sit within the DSRC radio box, as part of the front-facing piece that receives all incoming messages. Currently, they expect this technology to be available for OEMs to deploy as a minimum standard, but not made mandatory.

Other security activities are being conducted by the NHSTA who focus on regulations for vehicles. They are working on cyber security for autonomous and connected vehicles by providing design choices for vehicle architecture that minimises external threats.

The National Institute of Standards and Technology have also developed a cyber security framework (NIST, ND). They are considering developing a similar framework specific to C-ITS deployment to ensure road equipment is as protected as possible.

Privacy and protection of personal data

The US has aimed to address privacy issues in two ways. All personal information has been removed from the basic safety message transmitted by the vehicles. This includes driver number, licence plate number and even vehicle type. This exclusion has been regulated in the standards provided for basic V2V safety messages\(^79\). The trust

\(^79\) The relevant standards are SAE J2945 and J2735
management system also randomises the certificates used on messages and the MAC address used for the message. A government stakeholder felt that these measures would be sufficient, as more private information is already being given up by smartphones users.

Communication technologies

A government stakeholder noted that the type of communications technology used will be driven by the performance criteria required for each service. For example, vehicle platooning will require high speed communications so might use DSRC, whereas traffic light signals are less demanding so might use cellular.

The U.S. DOT approach is to identify a range of technologies that are suitable for each application and then let the users implement any technology that does not negatively impact on safety.

The spectrum used for communications is another potential issue identified by the government stakeholder. The US has reserved the 5.9 GHz spectrum for DSRC, but if other technologies were given access to this spectrum (a decision is yet to be made by the FCC) sharing strategies would need to be devised to prevent interference. At this point they have not identified whether LTE C2X will interfere with DSRC, but this was tested in San Diego in December 2017.

Interoperability

The U.S. DOT has not yet set standards at an application level for V2I communications. There are standards for V2V and V2signal, but they need standards for V2I for some applications, such as weather information. There are currently deployment projects providing road weather warnings, but standards are needed to ensure that these services are interoperable across geographical locations.

The U.S. DOT is bringing different stakeholders together in quarterly working group meetings to help develop and agree upon data requirements to support similar applications. This information is fed into the standards bodies such as the SAE to work towards a standard.

Compliance testing

In the US, OEMs are required to certify that their vehicles meet the safety regulations and standards, and ensure interoperability, including the respective C-ITS applications. The federal government can recall vehicles if they are not compliant.

Compliance is also achieved through OmniAir (OmniAir Consortium, 2017). OmniAir was initially seed-funded by the U.S. DOT, but no longer requires funding as they have a successful certification service. The U.S. DOT is currently working with OmniAir to provide certification for C-ITS suppliers that comply with the relevant standards. This is a successful example of the development model used by the U.S. DOT, where initial funding is provided until a level of interest has been reached that the project can be financially self-sufficient.

Continuity of services

The U.S. DOT is ensuring continuity of service by requiring all projects they fund to use the available standards for V2V communication technology. One challenge that they have faced, according to a government stakeholder, was to ensure that all projects use harmonised security credentials to sign their messages. A nationally operational security credentials management system is currently being piloted across all current projects.

Coordination

The U.S. DOT shares the lessons learnt from research and deployment projects with new C-ITS deployment projects through various tools.

Regarding centralised governing bodies such as those envisaged by the EU, a government stakeholder noted that the vehicle side of deployment will be led by OEMs through industry consortiums. The long-term role for the U.S. DOT will be to provide monitoring and oversight for C-ITS deployment once the OEMs have agreed what they
are delivering. On the infrastructure side, federal support may be required to ensure communication between the different governmental levels. They expect further work will be required to ensure common application of C-ITS services across all 50 states.

**Enabling environment**
The U.S. DOT creates an enabling environment by providing opportunities for research funding and support. A government stakeholder noted that they have not yet provided a business case for local deployment, which is key to further infrastructure deployment by local authorities. The business case for V2V deployment is better understood for its benefits in automation and V2V crashes. There are some stakeholders who feel that V2I deployment could be ignored and instead that the focus should be on V2V. The government stakeholder noted that at some point they will have to decide whether V2I technology is mature and valuable. They were not able to keep funding V2I research and deployment if there was not a business case based on the benefits to road safety.

**Other barriers, issues or challenges**
A government stakeholder noted that there was still an ongoing challenge in deciding whether to deploy infrastructure or vehicle technology first. Initially, the U.S. DOT thought that the infrastructure should come first. However, this would have costed an estimated $4 bn, so they switched to advocating for vehicle technology deployment. This led to the proposed mandatory inclusion of DSRC equipment in new vehicles, but even if the regulation goes ahead it will take 15 years to reach 95 percent deployment. The U.S. DOT is currently trying to advocate both infrastructure and vehicle deployment, and aiming to gain sufficient traction in both areas. A key goal is to create a business case for states to deploy the infrastructure without Federal assistance.

The U.S. DOT has been encouraging states and local authorities to include DSRC infrastructure when upgrading existing road infrastructure. The incremental cost of adding DSRC while upgrading a road is much less than installing it at separately a later point independently.

**D.11.6. Concluding remarks**
The NHTSA’s Advance Notice of Proposed Rulemaking sets out a logic for making certain V2V technology mandatory in light vehicles: the expected safety benefits of this technology are high, but the probability of any manufacturer deciding to invest in this technology unilaterally is low, and therefore without mandatory standards, market failure is likely (U.S. DOT, 2014b).

The NHTSA has also acknowledged that this approach may have its disadvantages – for example, it asked stakeholders as part of its Advance Notice of Proposed Rulemaking whether they believed the U.S. DOT’s regulatory endorsement of DSRC might “crowd out” other viable technologies, for example (U.S. DOT, 2014b).

The agency has also drawn attention to a number of outstanding or potential issues with its plans for deploying C-ITS which may have close parallels in any future EU deployment plan:

- One such issue is consumer acceptance. For example, if C-ITS systems depend upon regular servicing to maintain their effectiveness, but some consumers decide they would rather leave their broken systems rather than take their car in for servicing (for example updates to security certificates), the benefits of C-ITS will be compromised.

- Consumers may also need to be convinced that their privacy will not be jeopardised, and so the NHTSA’s proposals are for a system in which it is not possible to identify individuals or track their movements over time using the C-ITS system.

- Another issue is that the OEM industry has concerns about their liability increasing if they are deemed responsible for the products they create communicating effectively with products in vehicles they may not have created.
However, the NHTSA argues that the liabilities manufacturers face would just be analogous to those they face already.

- The possibility of V2V **communications congestion** has also been raised – so far, pilot studies have involved a limited spatial density of C-ITS vehicles. In dense urban environments, the NHTSA warns, spectrum congestion could conceivably become an issue. The NHTSA proposes further testing to gather evidence on this issue.

- The American spectrum regulator, the Federal Communications Commission (FCC), is considering **opening the 5.9 GHz range** currently reserved for C-ITS to unlicensed WiFi devices (IEEE 802.11 media access control, MAC, and physical layer, PHY, specifications). A similar plan is also under consideration in the EU. The NHTSA states that the possibility of such devices interfering with C-ITS if they share the same part of the spectrum is being investigated, with tests conducted in December 2017.

- The type of V2V system envisaged by the NHTSA would also require a **security and communications sub-system** to be set up. The creation, funding and management of that system is an outstanding issue, although the NHTSA has stated that it believes a private company may be interested in operating such a system.

- The NHTSA also has outstanding questions about how to set appropriate **test procedures** and **performance requirements**, and is still investigating **driver-vehicle interface issues**. The U.S. DOT funds programmes of research in each of these areas.
D.12. CASE STUDY: Australia

D.12.1. Overview and Key Messages

“As Australia is positioning itself to be an early adopter of developments undertaken internationally in the C-ITS space, applications deployed in Australia would be based on those applications deployed internationally, at least in the initial deployment period. Following that, Australia could evolve into a position where it could influence the development of applications to be deployed on the standardised platform that address specific areas of interest to Australia and may also be relevant to other international regions.”

(Austroads, 2012)

As a country without a significant automotive industry, Australia has been closely following the development, deployment and standardisation activities in the US and the EU. Given that its automotive standards and radio spectrum allocation resemble those in the EU, Australia seeks to follow European standards for C-ITS deployment as the default option. The association of Australian road operators, Austroads, has been designated by the central government of Australia and New Zealand to lead and coordinate C-ITS related activities. Austroads is an associated member of the C-Roads Platform and is involved in the discussions and working groups that entails.

Austroads also work closely with the National Transport Commission (NTC), which is a Federal agency that contributes to the achievement of national transport policy objectives by developing regulatory and operational reform of road, rail and intermodal transport.

Australia closely follow the EU approach for C-ITS deployment, adopting the European ITS FRAME architecture. Australia are expected to adopt similar standards and specifications to the EU, working closely with EU stakeholders developing these policies.

D.12.2. Policy approach

The Australian government describes itself as a “relatively small player in the global ITS space” – Australia’s GDP is equivalent to approximately 10 percent of the United States’, and Australia imports most of its vehicles, implying that the ability of Australia to take a leading role in C-ITS is very limited. Accordingly, the Transport and Infrastructure Council’s strategic plan states that Australian ITS architecture must be “consistent with global developments” (SCOTI, 2012), and Austroads has set out a strategic approach for C-ITS which consists firstly in adopting another region’s standards, and secondly contributing to the future development of those standards in a way that benefits Australia, as described in the quote above.

Austroads has acknowledged that it would be unwise for Australia to attempt to “mix and match” US and EU C-ITS standards, therefore, the country faced a choice between adopting a set of EU standards covering an extensive range of applications which are further away from deployment, or adopting US standards which are associated with a smaller set of (mainly safety-related) applications that are nearer readiness for widespread deployment (Austroads, 2015). Australia decided to follow EU standards due to a variety of reasons:

- Australia has a national policy to adopt UNECE standards for cars, i.e. Australian cars are designed to European specifications.
- Several private toll roads operators using 5.8 GHz DSRC system are active in Australia, which is similar to Europe but different to the U.S.
- The Australian radio channel allocation is very similar to the EU’s. It would not be possible for Australia to adopt US control channel allocation.

The Austroads’ National ITS Architecture (NIA) Roadmap was published in 2016. Stage 1 of the Roadmap involved adopting the European ITS FRAME architecture as a basis for the Australian NIA Framework (Austroads, 2016). The NIA supports a common
approach for planning, defining, and integrating ITS across a range of applications and stakeholder groups. The NIA Framework has already been implemented by various Austroads members, and further interest has been expressed by a number of industry stakeholders.

D.12.2.1. **Objectives**

The Transport and Infrastructure Council is the Australian government entity with overall responsibility for developing Australia’s ITS strategy. Concerning C-ITS in particular, the Transport and Infrastructure Council chose to delegate responsibility for developing a C-ITS strategy to Austroads. The objectives that Austroads put forward in its C-ITS strategy are reproduced in Table D-4.

**Table D-4: Objectives in Austroads’ C-ITS strategic plan**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>How the objectives of C-ITS would be achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deploy C-ITS in Australia in line with international developments (i.e. between 2016 and 2020, most likely to follow Europe)</td>
<td>By keeping up-to-date with international developments in C-ITS and positioning Australia such that it is able to adopt and adapt the various requirements developed internationally that are needed to successfully deploy C-ITS and enable it to function such that the C-ITS applications and benefits can be rolled out to the Australian community.</td>
</tr>
<tr>
<td>Improve road safety</td>
<td>By vastly improving risk detection and its notification to vehicles and drivers through advanced driver assistance information services and applications.</td>
</tr>
<tr>
<td>Enhance mobility and access</td>
<td>By offering increased convenience, mode choice and access to services.</td>
</tr>
<tr>
<td>Improve transport efficiency, reliability and productivity and therefore improve the productivity of the nation through improving the productivity of its road network</td>
<td>By providing for the efficient movement of people through enhanced public transport services, and goods through enhanced logistics and routing, and by improving the management of traffic through the use of enhanced transport network performance information. Through more efficient use of transport infrastructure and optimising freight (logistics) and public movement, the productivity of the nation can be increased, as gains in the productivity of the road network will transfer to overall productivity gains.</td>
</tr>
<tr>
<td>Improve social and environment-related transport outcomes</td>
<td>By providing information, system interventions and services to aid road users to reduce their energy consumption and emissions.</td>
</tr>
<tr>
<td>Improve transport network resilience</td>
<td>By providing systems to enable the road network to recover from a decline in traffic flow and have the road network</td>
</tr>
</tbody>
</table>
Objectives | How the objectives of C-ITS would be achieved
--- | ---
Contribute to the international C-ITS arena | operating at its full potential when it is required most.

By being an active and valuable contributor to various international C-ITS related committees and by developing and undertaking trials, and testing of C-ITS applications and devices that are proposed to be deployed on to the global platform.

Source: (Austroads, 2012)

The C-ITS strategy is part of a wider national policy and strategy framework that has been developed to support a coordinated approach for the ITS industry. The key documents include:

- Policy Framework for Intelligent Transport Systems in Australia: A policy document endorsed by all Australian Transport Ministers at the Standing Council on Transport and Infrastructure;
- National ITS Industry Strategy: Prepared by ITS Australia with input from industry and government stakeholders to provide a strategic framework for the wider ITS industry. The inaugural industry strategy was first released in 2009 – given the rapidly evolving nature of ITS technology and policy implications, it was revised again in 2012.
- Austroads Strategic Plan 2016-2020 (Austroads, 2016): Outlines the near-term strategy for Austroads, including using new technologies and innovations in the connected and autonomous vehicle space. The plan includes these advances under the Safety and Network programmes.
- National Policy Framework for Land Transport Technology: Action Plan 2016-2019 (Transport and Infrastructure Council, 2015): A policy document created by the Transport Infrastructure Council which includes a number of action points including: developing a C-ITS infrastructure roadmap, publishing a C-ITS statement of intent on standards and deployment models, and developing a nationally agreed deployment plan for security management of connected and autonomous vehicles. Austroads are responsible for assisting and delivering some of these actions.

The Industry Strategy promotes three core pillars of safety, mobility and the environment, in order to align with the national programme of transport reform.

### D.12.2.2. Stakeholders involved

Australia has a federal system of government and therefore there are at least two layers of government involved in C-ITS policy; the governments of Australia’s States and Territories, and the Commonwealth (national) government. A third layer, local government, may also play a role in deployment initiatives.

Australia’s geographic position, the size of its economy relative to the EU, the US and Japan, and its dependence on automotive imports mean that foreign stakeholders are likely to play an extremely significant role in the future development of C-ITS in Australia: experts anticipate that much of the work on developing ITS standards and technology will take place outside of the country. The Australian government intends to focus on influencing this work to the benefit of Australia and later potentially adapting EU or US standards and technology to fit Australian needs (SCOTI, 2012). According to stakeholders, the EU approach is now being followed, at least as a default option.
To date, the private sector has been involved to the extent that it has been consulted by the government on future C-ITS policy, and some private sector organisations, such as commercial vehicle operators, have been involved in government-funded C-ITS trials.

A list of major stakeholders is given below.

**Government**

- The **Department of Infrastructure and Regional Development** is the commonwealth (i.e. national) government department responsible for transport in Australia.
- The **transport departments of the State and Territory governments** have a significant role to play in the development and implementation of transport policy in general, including C-ITS policy, as Australia has a federal system of government.
- The **Transport and Infrastructure Council** brings together Commonwealth, State, Territory and New Zealand Ministers responsible for transport and infrastructure issues (as well as the Australian local government association) to help progress nationally significant reforms in transport policy.
- **Austroads** (whose members include the Australian commonwealth government department responsible for transport, as well as the Australian state government departments for transport, the New Zealand Transport Agency, and the Australian local government association) provides *expert technical input* into national policy, and promotes best practice and harmonisation of practices of its road agency members. Austroads was designated the interim C-ITS management entity from 2012 onwards (Austroads, 2012).
- The **NTC** is an independent public body set up to help deliver transport policy objectives by delivering regulatory reforms across state and commonwealth government. It has previously investigated prospective regulatory policy barriers to the deployment of C-ITS.
- The **Australian Communications and Media Authority (ACMA)** is the radio spectrum regulator in Australia and has placed a block on new non-ITS uses of the 5.9 GHz range and recognised the potential future use of that part of the spectrum for DSRC C-ITS (National Transport Commission, 2013).

**Other Australian stakeholders**

- Austroads organises biannual meetings with an Industry Reference Group on C-ITS involving over 30 senior representatives, e.g. from auto industry association, providers of traveller information services, mapping companies, suppliers, DSRC providers, satellite communication industry, Commonwealth Government etc. This is essentially a consultation forum.
- A key difference compared to the US and Europe is that there is no significant auto industry which makes close contact with vehicle technology developers more challenging. Therefore, in the Australian policy strategy there is little focus on technology development and more on following international developments to put the appropriate framework in place. In 2011, 30 percent of Australian car imports came from Japan, 23 percent from the EU and 15 percent from North America (Hutchens, 2013). The share of the market accounted for by Australian-based plants has been in steady decline for many years and the last three auto manufacturers remaining in Australia are expected to cease production soon (Mellor, 2014) (Austroads, 2014a).

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80 Previously the Strategic Council On Transport Infrastructure (SCOTI)
- The Australian Logistics Council, the Truck Industry Council and ITS Australia are among the organisations that have been consulted by the public bodies developing ITS policy in Australia (National Transport Commission, 2013).

- Non-government stakeholders have also been brought in to deliver deployment and trials of C-ITS systems, for example Transmax and ITS Australia worked with the Queensland Government to deliver a project to provide emergency vehicle priority at intersections (Transmax, 2015). A number of commercial vehicle operators are currently involved in a trial of V2V and V2I applications for heavy vehicles in New South Wales (Transport for NSW, 2015).

- In the future, a large number of different types of stakeholders may be involved in C-ITS; Austroads has attempted to enumerate them all (see Figure D-4).

**Foreign stakeholders**

- The most relevant Standards Development Organisations (SDOs) for Australia are CEN, ISO and ETSI (whose standards are being adopted in the EU) and IEEE, and SAE (whose standards are being adopted in the US). According to Austroads, most involvement is with ISO TC204 where Australia follows international developments closely. There is not much direct contact with CEN, ETSI or IEEE/SAE. However, Austroads is also actively involved with the EU-US Harmonisation Task Group 6 (security).

**D.12.2.3. Timings**

Yet, the Australian government has not adopted a firm deadline for widespread deployment of C-ITS applications. However, work has begun on establishing the foundations of that deployment, for example by beginning to consider what the national ITS architecture should be and what sets of C-ITS standards Australia should adopt. The Government is also undertaking a small pilot project to deploy C-ITS applications on a limited scale in New South Wales.

**National initiative**

Austroads’ C-ITS strategic plan, which was published in 2012, proposed a five year "concept" of the path to deployment of C-ITS in Australia, although the calendar date of year one was not specified. The strategic plan states that the government saw itself as "approaching year one" but that the timing of tasks was dependent on international developments. The five-year plan concept is reproduced in Figure D-3.

Australia are currently only carrying out pilots and trials and have no official deployment in any states. It is not clear when national deployment might begin.
Progress to date

Austroads has taken the following steps to progress the adoption of architecture and standards for C-ITS:

Set out a vision for a national ITS architecture (Austroads, 2014a).


Developed a business architecture for ITS (Austroads, 2014b), which among other things involved identifying all types of organisations that might be involved in the delivery of ITS services in Australia (see Figure D-4).

The government’s biggest trial of C-ITS deployment in Australia (the Cooperative Intelligent Transport Initiative (CITI)) is currently underway in New South Wales.

Austroads is currently working on defining initial system requirements on the following core functional areas for C-ITS:

- Spectrum management and device licencing
- Standards to adopt and compliance
- Security management (Austroads participation in EU-US Harmonisation group)

This process will involve coordination with European partners, as a result of following the EU C-ITS framework. Regarding the spectrum band reservation, the Australian Communications and Media Authority (AMCA) released a consultation paper in August 2016 regarding the proposed regulatory measures for the introduction of C-ITS in Australia. Specifically, the measures involved issuing a new class licence for C-ITS to use the 5.9 GHz frequency, referring to similar standards developed in Europe. AMCA released the final version of the documentation for authorising the 5.9 GHz frequency.

Ref: Ricardo/ED10644/3
for C-ITS in December 2017 (Australian Communications and Media Authority, 2017), which allows the spectrum to be used for trials and testing.

**Figure D-4: Organisations identified in Austroads’ ITS business architecture as being involved in delivery of ITS services**

Source: (Austroads, 2014b)

### D.12.3. Targeted C-ITS applications

The CITI project involved trials of a limited number of V2V and V2I C-ITS applications. Additionally, in 2011 Austroads identified a wider set of applications which it believes will be of interest to Australia, most of which contribute to road safety. These applications are listed in Table D-5. Austroads has encouraged the country’s national and state road agencies to focus on preparing business cases and trials for the adoption and deployment of these applications.
Table D-5: Specific C-ITS applications identified by Austroads as being of interest to Australia

<table>
<thead>
<tr>
<th>Application name</th>
<th>ETSI use case code</th>
<th>Principal benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intersection collision warning</td>
<td>UC003</td>
<td>Safety</td>
</tr>
<tr>
<td>Motorcycle approaching warning</td>
<td>UC004</td>
<td></td>
</tr>
<tr>
<td>Collision risk warning</td>
<td>UC012</td>
<td></td>
</tr>
<tr>
<td>Regulatory/contextual speed limits notification</td>
<td>UC018, UC012</td>
<td></td>
</tr>
<tr>
<td>Traffic light optimal speed advisory</td>
<td>UC019</td>
<td></td>
</tr>
<tr>
<td>Driver fatigue for light and heavy vehicles</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Enhanced route guidance and navigation</td>
<td>UC021</td>
<td>Network Efficiency</td>
</tr>
</tbody>
</table>

Source: (Austroads, 2011)

D.12.4. Deployment and key results

D.12.4.1. The Cooperative Intelligent Transport Initiative (CITI)

CITI is a $1.65M (€1.1M) trial of V2V and V2I C-ITS deployment for heavy vehicles using a 42km road freight corridor in New South Wales. The trial is the first large scale test dedicated to heavy vehicles, and will establish the first semi-permanent test area in Australia for C-ITS. 83 percent of funds will come from national and state government, and the remaining 17 percent will come from a research institute known as National ICT Australia.

During the trial 30-60 vehicles will be fitted with DSRC transceivers to benefit from the following specific applications:

- V2V: Intersection collision warning, forward collision warning and heavy braking ahead messages
- V2I: Advance warning of red lights, and in-cab messages for truck and bus speed limits at a particular location

Partners involved in this trial include the Port Kembla authority which is helping to provide access to local infrastructure, and several commercial vehicle operators who have agreed to have their vehicles fitted with the DSRC devices. Vehicles began to be equipped in 2014 this will continue throughout 2015. Results will be gathered over the next couple of years but the project may be extended for several years beyond that (Wall, 2013; Transport for NSW, 2015).

According to a stakeholder, the project was chosen for the following reasons:

1. Very unique geographical location: Port Kembla-Sydney corridor has lots of freight trucks and a portion of the road goes up a steep cliff, posing a number of safety issues (tight turns, steep inclines). The project can help identify technology solutions and be a test bed for technologies.

2. Trucks tend to be easier to fit equipment to. Moreover, they have high mileage (e.g. Port Kembla to Sydney every day). It has been fairly easy to sign up several freight companies to become involved.

The location has been a challenge in terms of setting up DSRC and satellite positioning. Some road parts are without electricity access, which is reflective of the wider situation on many Australian roads. Moreover, obtaining a ‘scientific’ permission for use of the 5.9 GHz spectrum band entailed administrative difficulties. The project previously

Ref: Ricardo/ED10644/3
followed the U.S. communications standards but they are switching to EU standards. The spectrum is currently embargoed but not allocated to C-ITS applications yet.

**D.12.4.2. Connected Vehicles and Automated Vehicle Initiate (CAVI)**

The Queensland Department for Transport and Main Roads is conducting the CAVI pilot project, which started in 2017 and runs until 2021 (Queensland Government, 2017). CAVI aims to test both C-ITS and automated driving. This project is the largest on-road C-ITS initiative in Australia, and the project aims to test interoperability between suppliers over a 9 to 12-month trial period during which both V2V and V2I C-ITS services will be tested.

This project includes 15 officers with extensive experience in engineering, security, project management, procurement and securing suppliers. The project is currently in the planning and design stages working with 4 suppliers for C-ITS stations. The aim is to have 500 vehicles equipped with C-ITS by 2019 and to upgrade traffic signal controllers and ITS cabinets to be C-ITS enabled. The pilot project is based in the city of Ipswich.

**D.12.4.3. Other C-ITS deployment**

There are a number of other C-ITS deployment trails taking place across Australia and New Zealand. These include:

- The Victoria Government offers an Intelligent Transport System Transport Technology Grant Program, which provides funding to industry for deployment of C-ITS applications.

- In Adelaide, South Australia, the Future Mobility Lab Fund is a $10m programme for developing, testing and demonstrating CAV, V2V, V2I and V2X technologies. Notably, there is a trail of Cohda wireless V2X technology.

- Bluetooth in-car messaging is being trialled in New Zealand to send real-time relevant, and localised messages to visiting drivers.

**D.12.4.4. Expected safety benefits from C-ITS applications**

Austroads published a report on the safety benefits of C-ITS and automated driving in Australia and New Zealand (Austroads, 2017). The report took four C-ITS applications and evaluated the potential benefit of these technologies in terms of road safety, shown in Table D-6. However, the report also notes that there are not currently any vehicles available on the market with C-ITS equipment in Australia or New Zealand.
Table D-6: Analysis of reduction in real-world crash types and serious injuries from C-ITS applications

<table>
<thead>
<tr>
<th>C-ITS Application</th>
<th>Type</th>
<th>Crash types</th>
<th>Reduction targeted in crash</th>
<th>Projected annual savings in FSI crashes (Australia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperative Forward Collision Warning (CFCW)</td>
<td>V2V</td>
<td>Same direction</td>
<td>20-30%</td>
<td>515-805</td>
</tr>
<tr>
<td>Curve Speed Warning (CSW)</td>
<td>V2I</td>
<td>Run-off-road, head-on (major roads)</td>
<td>20-30%</td>
<td>75-115</td>
</tr>
<tr>
<td>Intersection Movement Assist (IMA)</td>
<td>V2V</td>
<td>Adjacent direction</td>
<td>35-50%</td>
<td>940-1470</td>
</tr>
<tr>
<td>Right Turn Assist (RTA)</td>
<td>V2V</td>
<td>Right turn against</td>
<td>25-40%</td>
<td>525-825</td>
</tr>
</tbody>
</table>

Source: (Austroads, 2017)

D.12.4.5. Expected long-term results of total deployment

Austroads performed a basic analysis (Austroads, 2011) of the potential benefits of C-ITS in Australia, on the basis of a review of available evidence about the safety benefits of C-ITS at that time, in combination with contemporary road accident statistics for Australia. This review indicated that there are approximately 29,000 serious casualties of road accidents each year in Australia, and estimated that the total deployment of just four specific V2V applications could prevent 7,500 to 10,350 (25 percent to 35 percent) of these casualties. The assumed distribution of casualties prevented by type of collision is shown in Table D-7.

Table D-7: Assumed potential for reducing serious casualties with DSRC C-ITS in Australia

<table>
<thead>
<tr>
<th>Collision classification code</th>
<th>Description</th>
<th>Serious casualties per annum</th>
<th>Assumed prevented % by DSRC C-ITS</th>
<th>Serious causality prevented by per</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCA 11x</td>
<td>Vehicles from adjacent directions (e.g. intersection “cross traffic”)</td>
<td>4,300</td>
<td></td>
<td>2,250-3,100</td>
</tr>
<tr>
<td>DCA 12x</td>
<td>Vehicles from opposing directions</td>
<td>4,650</td>
<td>52%-72%</td>
<td>2,400-3,350</td>
</tr>
<tr>
<td>DCA 13x</td>
<td>Vehicles from the same direction (“nose to tail” collisions)</td>
<td>5,100</td>
<td></td>
<td>2,650-3,650</td>
</tr>
<tr>
<td>DCA 15x</td>
<td>Overtaking</td>
<td>300</td>
<td></td>
<td>200-250</td>
</tr>
</tbody>
</table>
### Collision classification code

<table>
<thead>
<tr>
<th>Description</th>
<th>Serious casualties per annum</th>
<th>Assumed prevented % by DSRC C-ITS</th>
<th>Serious casualties prevented DSRC by per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Others)</td>
<td>14,600</td>
<td>0%</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>28,950</td>
<td>25%-35%</td>
<td>7,500-10,350</td>
</tr>
</tbody>
</table>

*Source: (Austroads, 2011).*

---

**D.12.4.6. Barriers and challenges**

The following barriers and challenges were described by a Principal Engineer and Project Manager for Austroads. He is part of the Connected and Automated Vehicles team (CAV) which started in October 2016 following recognition by the Australian government that C-ITS and autonomous vehicles is an important field in the future of road transport.

**Security**

The team working on the CAVI project in Queensland are currently tendering for a Security Credential Management System (SCMS). So far, many companies have submitted interest in providing this product, which will be used for the 500 vehicles involved in the 2019 pilot trials.

He noted that Austroads are likely to select Public Key Infrastructure (PKI) over blockchain as part of their SCMS, but they are still researching which product and methodology will be best to implement. The National C-ITS Security Working Group was recently established to look after security related discussion and projects. Austroads is also following the EU approaches such as the Harmonisation Task Group.

**Privacy and protection of personal data**

Niko noted that privacy and protection of personal data issues are still in the early stages of discussion in Australia, but are mentioned in Action 6 of the National Transport Policy Action Plan (Transport and Infrastructure Council, 2015).

The Australian Federal government is looking into releasing official guidelines on this topic. Niko was aware of the GDPR in the EU, and had some concerns that this may impact some C-ITS station suppliers involved in CAVI who are European.

**Communication technologies**

Australia is planning to follow the EU strategy of adopting DSRC and C-V2X communication technologies. They will pursue a technology neutral approach, and aim for hybrid communications. DRSC is the current focus for safety-related issues as there is funding in this area, but Niko expected C-V2X to be important for non-safety-related services.

Some of the Australian cellular providers are looking into testing the network coverage across the whole country to ensure it is sufficient along road networks to provide national C-ITS services. Inland Australia has issues with physical infrastructure, such as no line markings for cars, unsealed roads and limited telecoms coverage, which could be problematic for C-ITS.

DSRC testing currently requires a research licence from the ACMA. The class licence for the 5.9 GHz spectrum is expected to be officially released in 2018, after which DSRC
testing in this frequency for C-ITS trial and deployment purposes (ITS G5 only at this stage) will be accessible to anyone without a licence.

**Interoperability**

The issue of interoperability is being considered by the various Austroads Working Groups and the Steering Committee, all of which are looking at how to ensure interoperability between the states. Niko felt that the pilots and trials are an important part of this process.

**Compliance testing**

Niko is responsible for developing a compliance assessment framework. The aim is to provide three or four options to the Federal government who will decide what option to pursue.

**Continuity of services**

Niko noted that Australia is looking to follow the EU in harmonising the C-ITS specifications to ensure backward compatibility, which he considers a key issue to continuity of services. They have a workshop planned in 2018 on the topic of harmonising the specifications, but he expects Austroads to follow and adapt the C-Roads specifications.

There are currently many different traffic, ticketing and parking management systems across the different states in Australia.

**Coordination**

Austroads leads coordination efforts on C-ITS in Australia. There is an Industry Reference Group that meet regularly through the year. This Group includes stakeholders from all relevant industries including the automotive manufacturers, suppliers, and the telecoms industry.

Austroads also has a Steering Committee who provide strategic direction for C-ITS activities, a Technical and Pilot Working Group who coordinate across the pilot projects, and a Security Working Group.

The findings and recommendations produced by these activities are fed back to the Federal government. The NTC provides policy based on their input. Austroads is more focused on producing technical guidelines and reports, and an NTC representative sits on the Steering Group to ensure there is no duplication of efforts between the two organisations.

**Enabling environment**

Niko felt that Australia currently has funding available for research and pilots in this area. There has been little resistance to funding CAV projects.

**D.12.4.7. Other barriers, issues or challenges**

Niko felt that finding a one system approach might prove problematic, as ensuring interoperability and harmonising the specifications could be a challenge. That said, the Steering Committee is aware of this challenge and is working to address it. Austroads are aware of the problems described above, and are trying to manage them in a step by step process by creating research projects and Working Group discussions.

**D.12.5. Concluding remarks**

As a country without a significant own automotive industry, Australia is dependent on industry developments from Europe, the USA and Japan, and tends to follow these closely. For C-ITS deployment, Australia has decided to follow EU standards and is looking towards the EU to take a lead, so that it can itself put standards and policies in place to allow similar technology to be deployed. Therefore, Austroads is in close cooperation with Europe, including following developments in certification, and standards adoption and learning from deployment.
D.13. CASE STUDY: Japan

D.13.1. Overview and Key Messages

Japan aims to be the world’s most advanced IT nation, and has strong Governmental support for C-ITS development and deployment. To achieve this aim, the government provides financial and policy support to encourage C-ITS deployment and movement towards autonomous vehicles. Japan aims to significantly improve the safety of its road transport, and use automated driving to achieve social goals such as providing accessible transport for an aging population.

The Ministry of Land, Infrastructure and Tourism (MLIT) is responsible for deploying ITS Spot, the roadside infrastructure for V2I C-ITS applications. The C-ITS services are received in vehicles by separate on-board unit (OBUs), most recently known as ETC 2.0. ETC 2.0 includes three basic services made available through the ITS Spot infrastructure; road traffic information, safe driving support, and electronic tolling. Vehicle Information and Communication Systems (VICS) are also used to provide safety messages and real-time traffic information to vehicles.

The C-ITS deployment in Japan has followed a more centralised, top-down approach, with the national government leading deployment by providing the roadside infrastructure themselves. The OBUs are quickly penetrating the vehicle fleet, with nearly 2.5 million ETC 2.0 units already in use. The VICS OBUs are used by 55 million vehicles, while the previous generation of ETC reached nearly 80 million units in use before being replaced by ETC 2.0.

D.13.2. Policy Overview

In 2013, the Japanese government published the “Declaration be the World’s Most Advanced IT Nation”, a policy strategy with the aim of increasing the use of IT in all areas of society and thereby making IT a key pillar for long-term economic growth in Japan (Harris, 2015). One of the elements of the strategy is the deployment of IT in transport, with a clear emphasis on cooperative V2I systems, which have been a priority area within Japan’s IT policy for a decade, as reflected in the yearly policy programme updates (IT Strategic Headquarters, 2015). The political emphasis for C-ITS deployment is around reducing the number of traffic fatalities - the Declaration aims to reduce fatalities to 2,500 or lower by around 2018, and become the society with the world’s safest road traffic by 2020.

Under the Declaration to be the World’s Most Advanced IT Nation, a Basic Plan for the utilisation of public and private data was announced in May 2017 (Prime Minister of Japan and his Cabinet, 2017). The purpose of this was to create a model for utilising data where citizens are not necessarily conscious of the information technology or data collection, but can enjoy the benefits of the data (HIDO, 2017).

As a result of the ongoing high-level political support and field testing since the mid-2000s, “ITS Spot” V2I communication has been mass deployed in Japan since 2011. Some 1,600 roadside units communicate with on-board units fitted to cars. By July 2014, it was estimated that some 360,000 OBUs had been installed (MLIT, 2014), which clearly falls behind earlier projections of 5 million units within 5 years after introduction (MLIT, 2012).

In addition to the 5.8 GHz system, a 10 MHz spectrum within the 700 MHz range was reserved in 2011 for safety-relevant V2V and V2I applications, with field tests to take place between 2014 and 2016 (Morishita, 2014).

Following from the IT-Nation-Declaration, in 2014 the Prime Minister’s Cabinet Secretariat published the “Public-Private ITS Initiative/Roadmaps” document, outlining a C-ITS and automated driving strategy for the next 10 to 20 years (IT Strategic Headquarters, 2014). The Public-Private ITS Initiative/Roadmaps document has been updated annually thus far. A HIDO representative noted that ultimately Japan aims to proceed to connected and autonomous vehicles as the focus of ITS.
D.13.2.1. Objectives

The key objectives for the introduction of ITS services in Japan were reduced congestion and improved road safety. This led to the development of “ITS Spot” in 2011, a V2I roadside communication system that provides several ITS services that are described further below. Publications on the system focus on the benefit of improved traffic flows through real-time road traffic information in the context of space and budget constraints for further increases to the road network. Potential safety improvements through displaying of safety messages are mentioned afterwards (MLIT, 2014; TDLC, n.d.).

Similar key objectives apply in the forward-looking “Initiative/Roadmap” document (IT Strategic Headquarters, 2014). Both social and industrial policy objectives are formulated. The following social objectives are targeted:

- To be the society with the world’s safest road traffic by 2020 (annual fatalities to 2,500 or lower by 2018)
- To be the society with the world’s safest and smoothest road traffic by 2030, through automated driving systems which...
  - ...drive more safely than experienced drivers
  - ...choose the route, speed patterns and other parameters, allowing for optimum road traffic flow and significantly reduced traffic congestion
  - ...increase accessibility for the elderly

The industrial objective is for Japan to become the world leader in automated driving from 2020 onwards “through the public-private collaboration in expanding the export of ITS-related vehicles and infrastructure” (IT Strategic Headquarters, 2014). It is further planned to use the opportunity of the 2020 Tokyo Olympic and Paralympic Games to showcase innovations in automated driving (Ibid.).

D.13.2.2. Stakeholders involved

The IT Strategic Headquarters is part of the Japanese Prime Minister’s cabinet secretariat. It is responsible for formulating high-level strategies such as the “Declaration be the World’s Most Advanced IT Nation” (IT Strategic Headquarters, 2015). At a technical level, four Japanese government ministries are involved in the advancement of ITS in Japan.

The Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) appears to lead on the implementation of ITS Spot. It was responsible for installing the 1,600 road-side units (RSUs). The National Institute for Land and Infrastructure Management (NILIM) is also part of MLIT and responsible for carrying out research. NILIM is involved in the testing of C-ITS equipment and the drafting of technical specifications (FOT-NET, 2015). 11 OEMs and 19 manufacturers of on-board units have participated in the field trials in 2007 (Ibid.). In 2014, there were 15 OEMs and 9 manufacturers of OBUs offering ITS Spot-compatible navigation systems (MLIT, 2014).

The Japanese Ministry of Internal Affairs and Communications (MIC) is responsible for the field operation tests of 700 MHz ITS running from 2014 to 2016 (Morishita, 2014). Other government authorities involved include the Ministry of Economy, Trade and Industry (METI) which is in charge of promoting the automobile industry, and the National Police Agency (NPA) which is responsible for road traffic safety (Figure D-5).

ITS Japan is a major umbrella body led by the automotive and ICT industries with 250 members including local and central governments, universities, research institutes and associations.
Figure D-5: Overview of stakeholders involved in promoting ITS in Japan

D.13.2.3. Timings

The key timings in the development of C-ITS deployment in Japan can be summarised as follows, based on FOT-NET (2015) and TDLC (n.d.):

- 1996: Introduction of Vehicle Information and Communication System (VICS) which provides drivers with public road traffic information, collected from road operators and police control centres in Japan.
- 2001: Introduction of Electronic Toll Collection (ETC) which operates based on 5.8GHz DSRC, analogous to toll collection systems in Europe.
- 2004: Development of Smartway proposal "ITS in the Second Stage - Smart Mobility for All" recommending full-scale ITS adoption by 2007.
- 2005-2006: Technical specifications and standards for OBUs and roadside equipment are developed by a joint research project of government together with 23 companies.
- 2008: Field trials throughout Japan.
- 2009: First car navigation systems compatible with ITS Spot are introduced to the market.
- 2010: “Technical Specification for the Spot Communications Services (DSRC Services)” published, MLIT starts installing 1,600 RSO based on these specifications and the trial experiences.
- 2011: ITS Spot services and collection of probe data are launched nationwide.
- 2011: 700 MHz frequency reserved for safety-relevant C-ITS applications (Morishita, 2014).
- 2015: ITS Spot rebranded ETC 2.0. The meaning of ‘ITS’ is not widely known in Japan while ETC is well known (TDLC, n.d.). Further functionalities added.
- 2014-2016: Field operation tests of 700 MHz C-ITS systems (Morishita, 2014).

In terms of future plans, the “Initiative/Roadmap” document sets out a fairly detailed timeline for the development and deployment of different technologies and applications, with the ultimate aim of introducing fully automated driving with no monitoring or...
support required before 2030. As an intermediate step, more advanced applications such as steering for collision avoidance are targeted for market introduction by 2017, and automated driving systems with emergency driver backup by the first half of the 2020s. The document also sets out, on which measures the public sector will lead (e.g. NPA to deploy infrastructure to all major intersections in Japan by 2018), and where the private sector will be in charge (e.g. development of alert terminals using V2V and V2I communications by 2017).

D.13.3. Targeted C-ITS applications

D.13.3.1. ITS Spot/ETC 2.0

Since 2011, “ITS Spot” V2I communication has been deployed in Japan. Some 1,700 roadside units communicate with on-board units fitted to cars. Initially, ITS Spot provided electronic toll collection (ETC) services through the ETC OBU, and information services through a vehicle information and communications systems unit (VICS). There are nearly 80 million ETC units in operation and nearly 55 million VICS units as of 2016 (HIDO, 2017). ITS Spot services have since been combined through the new ETC 2.0 OBUs which collect probe-vehicle data, and provide ITS services to the road users. The three basic services made available through the ITS Spot infrastructure are road traffic information, safe driving support, and electronic tolling.

ETC operates based on 5.8 GHz DSRC analogous to toll collection systems in Europe, and VICS which provides drivers with public road traffic information, collected from road operators and police control centres in Japan. ITS Spot combines and expands on these systems (see Figure D-6).

Figure D-6: Basic diagram of ITS Spot and its relation to VICS and ETC

Sensors --------> Patrol

VICS Center

<table>
<thead>
<tr>
<th>VICS OBU</th>
</tr>
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<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>ITS Spot Service Center System</th>
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<tbody>
<tr>
<td>ITS Spot (RSU)</td>
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<tr>
<td>ITS Spot Compatible OBU</td>
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<table>
<thead>
<tr>
<th>IC Card</th>
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<table>
<thead>
<tr>
<th>ETC System</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>ETC Toll Gate (RSU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETC OBU</td>
</tr>
</tbody>
</table>

Source: Kanazawa, et al. (2012)

A key feature is that not only is traffic information provided to vehicles, but vehicles also provide traffic information to the system (probe vehicle data). Data on location and speed is recorded for every 200 m and when the vehicle turns by more than 45° (and sent to road side units whenever these are passed). The system also records any acceleration/deceleration beyond 0.25G and any yaw rate beyond ±8.5°/s, thus capturing rapid steering manoeuvres. This helps traffic planners identify points of sudden breaking and quantitatively evaluate policy interventions such as traffic flows in the city with and without expressway tolls in place, or the reduction in sudden breaking once mitigating measures have been taken (MLIT, 2012b).

In terms of architecture, the Japanese DSRC-based system has fewer layers compared to the European architecture (Figure D-7). Following the OSI reference model, only three layers out of seven layers are specified: the physical layer, data link layer and application layer (Inria, 2013).
Figure D-7: Illustration of differences between Japanese and European ITS Station architecture

Source: Tsukada (2015)

The available ITS Spot services can be structured into the following categories: providing road traffic information, assisting safe driving, providing other information, ETC, collection of probe data, and Internet connection (Kanazawa, et al., 2012).

Road Traffic information: ITS Spot RSUs transmit real-time traffic data within the wider area and four different OBU applications using this data are available. The most important one is Dynamic Route Guidance which calculates quickest route to a given destination in current traffic. Other applications include showing current travel times to various destinations within a Prefecture in form of a diagram, and providing still images of current traffic on a variety of routes.

Safe driving assist: this includes "congestion tail information", "information on accident-prone locations", "information on road works, traffic restrictions and obstacles", "information on upcoming junctions", "weather information", "still image (road surface condition information, etc.)" and "emergency information". The key services are congestion and upcoming obstruction warnings, where a message is displayed on the driver’s navigation system and an acoustic warning is issued. This can help prevent accidents by alerting drivers to congestions behind a bend, or an accident in the lane ahead.

Figure D-8: Examples of ITS Spot warning messages

Source: MLIT (2012)

The Sangubasi Curve has been reported to have one of the highest number of traffic accident spots in the metropolitan expressway - MLIT report that the number of accidents has been reduced by approximately 60 percent as a result of ITS Spot providing congestion information before the curve (MLIT, 2012). They also note that 30 percent of congestion occurred at toll gates, and deployment of ETC and VICS has smoothed traffic and effectively eliminated the congestion at toll gates.

Other information: Congestion may arise due to drivers’ tendencies to lose speed on uphill road sections. An ITS Spot application reminds drivers to maintain their speed in these situations. A further ITS Spot application provides information on rest areas and the availability of parking around destinations.

Ref: Ricardo/ED10644/3
ETC: The electronic toll collection system has significantly reduced congestion in front of toll booths. The system can also be used for other cashless payment applications, for example in parking garages (MLIT, 2014).

Japan has also identified significant CO₂ emissions reductions from ITS. VICS has provided real-time traffic information to most of the vehicle fleet, and is estimated to have reduced CO₂ emissions by 2.4 million tonnes by 2009. Using ETC to reduce congestion at toll gates is estimated to save 0.21 million tonnes of CO₂ per year (MLIT, 2012).

Probe data collection: Probe data transmitted from the OBU to RSUs is stored in databases. Data on location and speed is recorded for every 200m and when the vehicle turns by more than 45° (and sent to road side units whenever these are passed). This helps understand what trips are made and how long they take and can help quantitatively evaluate policy interventions such as traffic flows in the city with and without expressway tolls in place. The system also records any acceleration/deceleration beyond 0.25G and any yaw-rate (rate of change of angular velocity (direction)) beyond ±8.5°/s, thus capturing rapid steering manoeuvres. These metrics can help traffic planners identify points of sudden breaking and adjust road design where needed. It can also help evaluate the impact of such measures by recording the reduction in sudden breaking once mitigating measures have been taken (MLIT, 2012b). Data from vehicles is collected anonymously and drivers can choose not to transmit probe data.

Internet connection: 96 percent of RSUs use non-IP connections. However, at some rest areas there are RSUs with an IP connection which enable the OBU to connect to the internet when the vehicle is parked.

Applications with ETS 2.0:

- Refinement and upgrade of current services
- Provide toll incentives for drivers to choose less congested routes on the Expressway network, depending on traffic situation.
- Monitoring oversize and overweight vehicles: provide incentives for heavy vehicles to stick to designated routes less vulnerable to road damage.
- Improved monitoring of commercial vehicle fleet by logistics companies, allowing greater efficiency in managing of loading/unloading at logistics centres.

**D.13.3.2. 700 MHz ITS**

In addition to the 5.8 GHz system, a 10 MHz spectrum within the 700 MHz range was reserved in 2011 for safety-relevant V2V and V2I applications (Morishita, 2014). The lower frequency has the advantage of larger coverage and less signal loss through physical obstacles such as buildings, making it more suitable for intersection scenarios (Inria, 2013). Field tests are scheduled to take place between 2014 and 2016, with a budget of $2.1 million allocated for 2014 (Morishita, 2014). To date, no publication detailing initial tests or their results has been identified.

Targeted applications focus on junction collision prevention as well as pedestrian protection systems (Figure D-9). Current field trials include testing of 700 MHz communications between cars and trams in Hiroshima and junction right-turn warning systems in Toyota city (Morishita, 2014).
Figure D-9: Targeted 700 MHz applications

Source: Morishita (2014)
D.14. References


Ref: Ricardo/ED10644/3


Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Annex E - Analysis of responses to the Open Public Consultation Report for DG MOVE
In November 2012, Ricardo plc acquired the assets and goodwill of AEA Technology plc and formed a new company, Ricardo-AEA Ltd. The entire capability and resources previously represented by AEA Technology plc were transferred to Ricardo-AEA, as were all employees. Consequently, where specific projects or track record referenced in this proposal were undertaken and completed prior to the acquisition, for contractual reasons, these continue to be identified as AEA Technology plc.
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<td>E.3.2.3</td>
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<td>Q7: Do you consider that any drivers underlying the problem are missing? Please elaborate (n=102)</td>
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<td>E.3.2.5</td>
<td>Q8. The Commission has established the following objectives for this initiative. From your point of view, how important is it to achieve these objectives? (n=133-136)</td>
<td>20</td>
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<td>Q12. To achieve the above objectives, different types of action could be foreseen (n=123-133)</td>
<td>32</td>
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<tr>
<td>E.3.2.10</td>
<td>Q13. Please elaborate on your answers to the previous question. In particular, if you favour EU action, please indicate what this needs to cover and what form it should take. Please also indicate if you think other (types of) action(s) should be considered to achieve the objectives (n=96)</td>
<td>38</td>
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<td>E.3.2.11</td>
<td>Q14. Please indicate if you agree with the following statements on accelerating deployment of C-ITS (when services are fully functional and EU-wide specifications are in place) (n=131-132)</td>
<td>42</td>
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</tr>
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<td>E.3.2.13</td>
<td>Q16. From your point of view, are there actions missing that should be considered at the EU level? (n=85)</td>
<td>48</td>
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<td>51</td>
</tr>
<tr>
<td>E.3.3.1</td>
<td>Q17: Please indicate your level of agreement with the following statements (n=134-136)</td>
<td>51</td>
</tr>
<tr>
<td>E.3.3.2</td>
<td>Q18. Please elaborate on your answers to the previous question (n=88)</td>
<td>53</td>
</tr>
<tr>
<td>E.3.3.3</td>
<td>Q19. From your point of view, are there any missing impacts that should be considered? (n=71)</td>
<td>56</td>
</tr>
<tr>
<td>E.3.3.4</td>
<td>Q20. Please indicate your level of agreement with this statement (n=132)</td>
<td>58</td>
</tr>
<tr>
<td>E.3.3.5</td>
<td>Q21: Please elaborate on your answer to the previous question (n=71)</td>
<td>59</td>
</tr>
<tr>
<td>E.3.3.6</td>
<td>Q22. What do you expect to be the main benefits to you / your organisation of substantial deployment of C-ITS? If possible, please include quantifiable examples (n=111)</td>
<td>61</td>
</tr>
<tr>
<td>E.3.3.7</td>
<td>Q23. What do you expect to be the main costs and burdens to you / your organisation of substantial deployment of C-ITS? If possible, please include quantifiable examples (n=95)</td>
<td>64</td>
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<tr>
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E. ANALYSIS OF RESPONSES TO OPEN PUBLIC CONSULTATION

E.1 Introduction

This is the report on the response to the Public Consultation (PC) for the “Support study for Impact Assessment of Cooperative Intelligent Transport Systems” reference MOVE/B4/2016-239 (hereafter the ‘project’).

This report is submitted by Ricardo and TEPR, the consultants appointed to conduct this study. This report provides a summary of the process and results from the Public Consultation.

The Public Consultation was launched by the European Commission (DG MOVE) on 10th October 2017 and was open for responses until 5th January 2018 (12 weeks). An extension for the receipt of responses was agreed until 12th January 2018 (bringing the total to 13 weeks).

This report contains the following sections:

- **Section E.2, Analysis of respondents’ profile:** A brief overall profile is provided of the respondents by stakeholder type, Member State and any other relevant characteristic requested in the questionnaire (such as their main area of professional interest), along with a comment on the size and representativeness of the sample. We have indicated also whether all stakeholder groups of interest have been sufficiently engaged;

- **Section E.3, Analysis of responses:** For each question, there is a graph presenting the responses to the closed question, as well as text to summarise the findings in the graph. We have highlighted any particular groups of stakeholders or regions that held particular views. Where stakeholders have been able to provide comments, we have provided a qualitative discussion of these.

- **Section E.4, Analysis and summary of ad hoc responses:** The final section summarises additional ad hoc responses: ad hoc responses, such as those from stakeholders who chose to provide a written response instead of answering the questionnaire, which is the approach typically taken by some Member States, as well as reports submitted to support a stakeholder’s questionnaire response. We have summarised Member States’ views separately from those of other stakeholders.

Please note that the views presented can only be associated with respondents to this specific consultation and may not be representative of the views of all or specific groups of stakeholders.
E.2 Analysis of respondents’ profile

A total of 139 responses to the questionnaire were received. The responses covered a variety of stakeholder groups, as shown in Table E-1.

Table E-1: Classification of stakeholders responding to the questionnaire

<table>
<thead>
<tr>
<th>Stakeholder group</th>
<th>Number of responses</th>
<th>% of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>On behalf of a private company</td>
<td>40</td>
<td>29%</td>
</tr>
<tr>
<td>On behalf on an association</td>
<td>37</td>
<td>26%</td>
</tr>
<tr>
<td>On behalf of a public authority (ministry, agency, other form of public administration, at national, regional or local level)</td>
<td>32</td>
<td>23%</td>
</tr>
<tr>
<td>As a citizen (in own capacity)</td>
<td>11</td>
<td>8%</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>8%</td>
</tr>
<tr>
<td>On behalf on a non-governmental organisation</td>
<td>8</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>138</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Notes: ‘Other’ is based on the respondents’ choice and includes: two research centres/institutes, an industry association, a public utility company, a road authority/operator cooperating within the European ITS Platform, a university researcher on C-ITS, a stakeholder with trade, business or professional association, a Polish municipal company, an MS expert, a citizen but as a nominated member state expert on C-ITS and a public Institution with Industrial and Commercial Character.

Responses were received from respondents residing in, or organisations based in 18 EU Member States (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Latvia, Luxembourg, Netherlands, Poland, Portugal, Slovak Republic, Spain, Sweden, and United Kingdom). A further 5 responses were received from Israel, Norway, Switzerland, and an EU-wide representative. The distribution of responses by country of residence or establishment is shown in Figure E-1. The largest number of responses was from Belgium and Germany, which contributed 56 responses between them (41% of the total).
In terms of the geographical distribution of respondents (EU-15 and EU-13 membership), the majority (119 out of 138; 86%) are from EU-15 Member States, with only 11 (8%) from EU-13 and eight from other countries including Norway, Israel, Switzerland and unknown.

The 139 respondents to the survey represent a broad range of interests that can be grouped into various subcategories (see Table E-2: Vehicle and equipment manufacturers/suppliers/repairers’ interests were indicated 33 times (23% of responses), followed by road and transport operators (18 times, 13%). The interests of ITS service providers and telecommunication were indicated, in total, 15 times (10%) with five more respondents referring to the interests of associations representing automotive replacement parts (4%). Authorities’ interests (including national, regional and local) were indicated 27 times (19%), together with four more referring to road authorities’ interests (3%). Another 21 responses also indicated interests in societal and/or consumer rights, research/academia/consultancies, or as road users.

We note that the number of responses (142) was greater than the number of respondents (139) because a few respondents associated themselves with more than one stakeholder group (three).
Table E-2: Classification of respondent interests (more than one response from respondents possible)

<table>
<thead>
<tr>
<th>Stakeholder Category</th>
<th>Number of responses</th>
<th>% of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle and equipment manufacturers/suppliers/repairs</td>
<td>33</td>
<td>23%</td>
</tr>
<tr>
<td>Road/transport operators</td>
<td>18</td>
<td>13%</td>
</tr>
<tr>
<td>Regional or local public authorities</td>
<td>14</td>
<td>10%</td>
</tr>
<tr>
<td>National Public Authorities</td>
<td>14</td>
<td>10%</td>
</tr>
<tr>
<td>Societal interests and/or consumer rights</td>
<td>11</td>
<td>8%</td>
</tr>
<tr>
<td>Research/Academia/Consultancies</td>
<td>9</td>
<td>6%</td>
</tr>
<tr>
<td>ITS service providers</td>
<td>9</td>
<td>6%</td>
</tr>
<tr>
<td>Telecommunications providers</td>
<td>6</td>
<td>4%</td>
</tr>
<tr>
<td>Associations representing automotive replacement parts</td>
<td>5</td>
<td>3%</td>
</tr>
<tr>
<td>Road authorities</td>
<td>4</td>
<td>3%</td>
</tr>
<tr>
<td>Unknown</td>
<td>3</td>
<td>2%</td>
</tr>
<tr>
<td>Road user</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>142</td>
<td>100%</td>
</tr>
</tbody>
</table>

Notes: Other is based on: insurers, car rental companies, vehicle and infrastructure testing/inspection and certification services, one NGO with a target group of citizens with mobility disabilities and another NGO coordinating road safety at national level, public and private sector representatives/organisations (including related to whole-life vehicle compliance), a stakeholder with cement and concrete interests in transport infrastructure, independent or MS experts, and an association.

In addition to the responses to the questionnaire, 46 additional contributions and position papers were submitted (discussed in Section E.4).

Following the introduction section, the questionnaire was split into three main sections: (1) background; (2) problem definition; and (3) impacts. Table E-3 below presents the total number of responses for each question in the three sections. A larger number of respondents provided answers to multiple choice questions compared to the free text responses.

Table E-3: Total number of responses for questions in Sections 1, 2 and 3

<table>
<thead>
<tr>
<th>Questions</th>
<th>(1) Background No. of responses</th>
<th>(2) Problem definition No. of responses</th>
<th>(3) Impacts No. of responses</th>
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<tr>
<td>Q1</td>
<td>136</td>
<td>Q4</td>
<td>135</td>
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<tr>
<td>Q2</td>
<td>135</td>
<td>Q5 (free text)</td>
<td>119</td>
</tr>
<tr>
<td>Q3</td>
<td>135-136</td>
<td>Q6</td>
<td>133-136</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Q7 (free text)</td>
<td>102</td>
</tr>
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<td></td>
<td></td>
<td>Q8</td>
<td>133-136</td>
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<td></td>
<td></td>
<td>Q9 (free text)</td>
<td>97</td>
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<td>Q10</td>
<td>132-135</td>
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<td></td>
<td>Q11 (free text)</td>
<td>78</td>
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<td>Q14</td>
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<td></td>
<td></td>
<td>Q15 (free text)</td>
<td>98</td>
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<td>Q17</td>
<td>134-136</td>
<td>Q18 (free text)</td>
<td>88</td>
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<td>71</td>
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<td>Q20</td>
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<td>Q20 (free text)</td>
<td>132</td>
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<tr>
<td>Q21</td>
<td></td>
<td>Q21 (free text)</td>
<td>71</td>
</tr>
<tr>
<td>Q22</td>
<td></td>
<td>Q22 (free text)</td>
<td>111</td>
</tr>
<tr>
<td>Q23</td>
<td></td>
<td>Q23 (free text)</td>
<td>93</td>
</tr>
</tbody>
</table>
Finally, the analysis of the responses also suggested that a total of 30 responses (22% of total responses) were coordinated, following a template for answers. In total, 11 different templates were identified from the analysis of the sample, as shown in Figure E-2.

All coordinated responses identified had two or three participants, except for Coordinated Response 1, which had seven participants. The majority of this group (six) were responding on behalf of an association (and one on behalf of a private company), and all represent interests in automotive replacement parts associations. The respondents reside in, or have organisations based in Belgium, Germany, Italy, Poland, Sweden and United Kingdom. Since respondents were free to adapt the answers to express their own views, coordinated responses have been analysed individually in the following sections.

Figure E-2: Distribution of the responses by stakeholder group – showing coordinated responses
E.3 Analysis of responses

In this section we present the responses to the main questions of the consultation. The responses are analysed in the subsequent sections as follows:

- Section E.3.1: Questions 1-3 (Background), 3 questions.
- Section 2.2: Questions 4 to 16 (Problem definition), 13 questions.
- Section 2.3: Questions 17 to 23 (Impacts), 7 questions.

When analysing the results of close-end questions, we present an analysis of the responses by all stakeholders to all options provided. Furthermore, due to the high number of options in some questions, we present a more detailed breakdown of the responses by stakeholder group for a selected number of questions, typically those with the highest share of positive or negative responses.

E.3.1 Background

E.3.1.1 Q1: How familiar are you with cooperative intelligent transport systems? (n=136)

Out of the 136 responses received, 88 (65%) indicated that they were very familiar with cooperative intelligent transport systems (Figure E-3). Forty-seven respondents (34%) stated they were somewhat familiar, while only one respondent indicated they were not at all familiar.

![Figure E-3: Response on familiarity of cooperative intelligent transport systems (n=136)](image)

As Figure E-4 highlights, when disaggregated by stakeholder group, the highest level of familiarity with cooperative intelligent transport systems was indicated by private companies and other types of stakeholders (29 out of 39 (74%) and eight out of 10 (80%) being very familiar respectively). Every stakeholder group had at least 50% of respondents that were very familiar, except for NGOs where only 38% (three out of eight) respondents stated this.
E.3.1.2 Q2: *How familiar are you with the ITS Directive and the EU actions to support the deployment of intelligent transport systems? (n=135)*

From the 135 responses received, 78 (58%) indicated that they were very familiar with the ITS Directive and EU actions to support the deployment of ITS, and a further 50 (37%) stated that they were somewhat familiar (see Figure E-5). In comparison, only seven respondents (5%) indicated they were not at all familiar with the directive and EU actions.

Figure E-6 shows that, when disaggregated by stakeholder group, the highest level of familiarity with the ITS Directive and EU actions to support the deployment of ITS was given by other types of stakeholders (eight out of 10; 80%). All other stakeholder groups had between 44% and 64% of respondents indicating they were very familiar and the remainder mostly having stated somewhat familiar. The stakeholder groups with respondents indicating they were not at all familiar were mostly private companies and public authorities, however this amount was small (three out of 39 and three out of 31 respectively).
Figure E-6: Response on the familiarity with the ITS Directive and EU actions to support the deployment of intelligent transport systems, by stakeholder group

E.3.1.3 Q3: How familiar are you with the following initiatives in the area of cooperative, connected and automated mobility? (n=135-136)

As shown in Figure E-7, a large proportion (between 67-95%) of respondents stated they were either very familiar or somewhat familiar with all initiatives shown, except for the initiative ‘EATA roundtable’ where only 44% indicated this. The initiative ‘C-ITS Platform’ had the largest familiarity with 88 out of 136 respondents stating they were very familiar, whereas this was 49-51 out of 135-136 for initiatives ‘C-ROADS Platform’, ‘GEAR2030’, ‘Horizon 2020’ and ‘Letter of Intent’, and only 28 out of 135 for the ‘EATA Roundtable’ initiative. The number of respondents who stated they were not at all familiar ranged from <1% for the ‘C-ITS Platform’ initiative to 56% for ‘EATA Roundtable’ initiative.

When analysing responses by different stakeholder groups, consensus between the stakeholders was identified in most areas. There was an almost identical split within each stakeholder group when looking at the most familiar ‘C-ITS Platform’, ‘Horizon 2020 research activities’, ‘Letter of Intent’ and the least
familiar ‘EATA Roundtable’ (see Figure E-8). For example, at least 52% of respondents from all stakeholders indicated they were very familiar with this initiative. A small number of respondents on behalf of private companies, public authorities and citizens indicated they were not at all familiar (one-three), however this is not considered significant.

Figure E-8: Response on the familiarity with the initiative ‘C-ITS Platform’ in the area of cooperative, connected and automated mobility, by stakeholder group

E.3.2 Problem definition

The next 13 questions of the PC cover the current C-ITS problem, which the Commission describes as follows:

“Today some C-ITS are already technically mature: the technological capabilities among market parties are increasing, and vehicle manufacturers intend to launch series of vehicles with selected C-ITS technology on board by 2019. However, the Commission considers that deployment is being delayed due to several barriers and uncertainties, and Europe risks seriously falling behind other regions in the world if it fails to act soon. Without a clear legal framework, C-ITS deployment is expected to remain slow and fragmented, resulting in interoperability issues and hindering continuity of services. This in turn will hinder the deployment and uptake of C-ITS and the realization of their full benefits, in particular with regards to road safety and traffic efficiency.”

E.3.2.1 Q4: Do you agree with the assessment above? (n=135)

Out of the 135 responses received, 110 (81%) indicated that they strongly agreed or agreed with the assessment above, in that C-ITS deployment is being delayed due to several barriers and there is a risk of Europe failing behind other regions unless a clear legal framework is put in place (see Figure E-9). Another 14 respondents (10%) stated that they neither agreed nor disagreed with this statement, while in comparison, only nine (7%) indicated they disagreed or strongly disagreed.
Figure E-9: Response on agreement of the assessment above in terms of current mature C-ITS technology and the need for a clear legal framework (n=134)

Figure E-10 highlights that, when disaggregated by stakeholder group, the level of agreement is split approximately equally, with at least 77% of respondents from all stakeholders having agreed or strongly agreed with the assessment. Private company, association, and NGO respondents were most strongly in agreement in terms of at least 50% indicating they strongly agreed. Respondents who disagreed or strongly disagreed were mostly from private companies, associations or public authorities, however this amount is small (1-10%).

Figure E-10: Response on agreement of the assessment above in terms of current mature C-ITS technology and the need for a clear legal framework, by stakeholder group

When analysed by stakeholder interest\(^1\), as shown in Figure E-11, the level of agreement was again split fairly equally, with at least 60% of respondents from all interests having agreed or strongly agreed with the assessment. Respondents with interests in vehicle & equipment manufacturers/suppliers/repairs, societal or consumer rights, research/academia/consultancies and

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\(^1\) Analysis by representing interest included only those respondents who indicated one representing interest (139 out of 142), to avoid double counting

Ricardo in Confidence
automotive replacement parts were most strongly in agreement in terms of at least 55% indicating they strongly agreed.

**Figure E-11:** Response on agreement of the assessment above in terms of current mature C-ITS technology and the need for a clear legal framework, by representing interest

![Bar chart showing response on agreement](chart.png)

**E.3.2.2 Q5: Please elaborate on your answer to the previous question (n=119)**

One hundred and nineteen respondents (86%) elaborated on their answer to the previous question. Thirty three of these were from associations, a further 37 were from private companies, 29 were from public authorities and seven each came from NGOs and from citizens. A further six came from respondents who categorised themselves as 'other'.

Three main issues were mentioned by respondents from associations that strongly agreed with the European Commission’s assessment:

1. the need for there to be access to in-vehicle data;
2. the need to provide clarity and certainty for investment; and
3. the need to ensure that the same C-ITS systems can operate across Member State borders.
A similar comment repeated by six European and national trade associations representing distributors of replacement automotive parts and diagnostic tools (and one private company) called for legislation to ensure interoperable access to the vehicle and its data, as well as the ability to exchange data remotely with the vehicle. It was argued that OEMs are currently developing specific solutions separate from their competitors, which will reduce consumer choice and lead to higher prices, thus not delivering the full benefits of C-ITS. If legislation were to address this, it was argued that it would lead to a wider variety of services from which authorities would be able to choose. Two other national associations in the same industries made a similar point, as did a European and national association representing insurers, which called for the Commission to build on the work of the C-ITS Platform in this respect.

Those strongly agreeing with the Commission’s assessment that called for action to improve the clarity of the legislative framework included two associations representing motor vehicle inspectors, which underlined the need for interoperability between all vehicles and all roadside units, as well as backward interoperability. Those emphasising the need for certainty for investors included associations representing automotive suppliers and road surfacing interests. A group representing ITS interests strongly agreed with the Commission’s assessment, as it supported the need for interoperability between vehicles, backward compatibility and also cross-border interoperability.

Those associations that agreed with the Commission’s assessment raised similar concerns to those associations that had strongly agreed, in addition to some others. Two associations representing transport operators provided a repeated response that without a certain level of common standards, there was a risk that monopolies of manufacturers and technology dependence might occur. An association representing road operators called for a clear legal framework to support investment, in general, and particularly in relation to the ITS G5 band of the radio frequency spectrum. A national consumers’ association highlighted the risk of fragmentation posed by the development of different legislative frameworks in different Member States. In this respect, they noted that while the General Data Protection Regulation (GDPR) applies to personal data, there is currently no similar framework for handling non-personal data.

A vehicle manufacturers association, supported by two manufacturers, raised concerns about the potential implications for manufacturers of the way in which the GDPR might be applied to C-ITS and the way in which the Draft European Electronic Communications Code covers C-ITS. While generally agreeing with the Commission’s assessment, an association representing telecommunications interests disagreed with the Commission’s assertion that the stated C-ITS technologies were technologically mature, highlighting fifth generation mobile communications technology. In this respect, it underlined that legislation should not prejudice the outcome of a market-led approach and so allow, and not disincentivise, the development of new technology. An association representing road operators also noted that the choice of technologies should be left to the market.

The interaction between different road users, including those not equipped with C-ITS technology, was raised by some associations. An association representing the bicycle industry noted that there is, as yet, no standard protocol to link modes to each other, although this was being developed in a non-integrated manner at the local and project level. A similar argument was made by an equipment supplier. While supporting the need for a relevant policy framework, an association representing consumers was concerned about the impact on road users not equipped with C-ITS, particularly vulnerable road users, and so called for legislative action only when there was a clear safety and environmental benefit for society as a whole. Another association representing road users, while also supporting the Commission’s assessment of the need for action, questioned the assertion that C-ITS would have an impact on road safety. A third association representing road users noted that there remain outstanding issues around costs and business models.

Four associations set out their reasons for neither agreeing nor disagreeing with the Commission’s assessment. A city network argued that the Commission’s assessment was relevant to motorways, but not to urban areas, where the problems are different and the main challenge is to understand which urban transport problems C-ITS can contribute to solving. An association representing public transport operators agreed with the need for a clear legal framework, and noted that this needed to harmonise and standardise communication exchanges, to promote the development of inter-compatible systems and to protect data and address cybersecurity. They did not support the assertion that the C-ITS technologies were mature, although noting that manufacturers were putting these onto the market. However, they were concerned that the debate was being led by manufacturers, often without the engagement of public transport operators, which risked ignoring how C-ITS could meet wider societal
goals. They also noted that the transition to a vehicle fleet that was fully equipped with C-ITS could take more than a decade, and that further consideration needed to be given to the implications of this. Similar concerns were raised by a public transport operator and an association representing transport companies, which had disagreed with the Commission’s assessment. An association representing road operators believed that the Commission’s assessment was only a partial view, as it did not reflect the real needs in the market, so risked leading to similar issues that have been experienced in relation to the European Electronic Toll Directive. They also argued that there was a need to protect and enhance what had already been done by many road operators.

Two associations representing telecommunication interests explained their reasons for disagreeing with the Commission’s assessment. One of these, while recognising the importance of a legal framework, underlined their support for a technology-neutral approach, so an approach under which market players, not policy makers, decided which technology should prevail. The other made a similar argument that specifying a specific connectivity option for C-ITS would not enable its full benefits to be realised, as it would potentially lock Europe into old technology standards, whereas the need for a clear path towards the potential benefits of 5G should be retained. A similar argument was made by an equipment supplier.

Similar themes were raised by private companies that strongly agreed or agreed with the Commission’s assessment. One supplier underlined that as their business was EU-wide, an EU policy framework was needed. Three companies noted that different approaches in different Member States was not conducive to EU-wide interoperability or to low costs, while three underlined the need for EU action to ensure cross-border interoperability. Several companies also noted that EU action was needed to address particular issues, including security (an ITS service provider), privacy and security (a supplier) and the need for an agreed a set of standards (a vehicle rental company). A vehicle inspection and certification company called for action to ensure that there was open competition and that all service providers, including third party providers, were treated in an equal, fair and non-discriminatory manner. A supplier noted that C-ITS should not put drivers that were not equipped with C-ITS at risk.

An ITS service provider, a vehicle rental services company and an aftermarket service provider raised the issue of access to in-vehicle data, calling for this to be ensured. The former also noted that the GDPR and the ePrivacy Regulation, which was under development, did not deal well with C-ITS, as they were based on out-of-date concepts. A vehicle manufacturer also noted that the GDPR and cybersecurity needed to be addressed. Another company underlined that GDPR was a useful first step, but did not go far enough.

Other issues each raised by a number of companies included the need for policy action to ensure the implementation of beneficial C-ITS technology (seven companies), which otherwise no-one would be willing to pay for, and to bring together actors in different industries that were not used to working together (two companies). Five companies raised the debate about which communications technology should be used. A vehicle manufacturer disagreed with the telecommunications industry’s desire to use the same bandwidth of the radio frequency spectrum that has been allocated to DSRC for C-V2X (5G). Four suppliers noted that this debate was potentially putting vehicle manufacturers off from taking decisions and so delaying the roll-out of C-ITS.

A company that had no opinion on the Commission’s assessment called for a better alignment between e-mobility and C-ITS, as the latter could act as an enabler for e-mobility solutions. Three companies explained why they had disagreed with the Commission’s assessment. A telecommunications provider argued that vehicle connectivity can be achieved by making the most of the fact that each car generally has at least one smart phone, and that there is a willingness on the part of manufacturers and road authorities to make data available. The company was concerned that the mistakes of the eCall Regulation, which they believed had locked in an outdated technology, will be repeated. A manufacturer disagreed as most of the Day 1 and Day 1.5 services are already being deployed in vehicles, while a consultancy felt that it would be a mistake to prescribe a solution for C-ITS at this point, as the technology cannot be considered mature.

A common issue raised by ten public authorities was the need for a policy framework that will provide clarity for investment, either that which they might undertake themselves, or which others might undertake. Three authorities noted that the debate over the alternative short-range communications technologies had not been helpful in this respect. One public authority underlined the need to invest in transport infrastructure, as well as in communications network infrastructure, in order to deploy C-ITS, while another noted the importance of avoiding the fragmented implementation of C-ITS. A third
suggested that the main obstacle was a lack of a “mutually, well-coordinated business model” involving government and the market.

A national ministry underlined that there was a need to take account of the situation in different countries when deploying C-ITS, while a national road office listed a number of issues that needed to be addressed, including data protection, balancing responsibilities between different stakeholders, cyber security and the coordination of different services and means of communication. One region involved in the roll-out of C-ITS noted that only vehicle manufacturers knew which C-ITS they were planning to implement in their vehicles, which it considered to be a challenge to introducing the right infrastructure. One municipality considered the lack of public support to be the most important obstacle to the roll-out of C-ITS, while also noting that the transition between motorway and urban areas has not been addressed and that many municipalities do not have the necessary skills, resources and infrastructure to support the roll-out.

Five public authorities explained why they neither agreed nor disagreed with the Commission’s assessment. One noted that developments are occurring, but that uncertainties around the ownership of vehicle-related data will hinder the roll-out of C-ITS, while the role of the public versus the private sector in deploying the digital infrastructure was not clear and often varies between Member States. A national ministry suggested that falling behind other parts of the world was not an issue, as nowhere was there a clear legal framework for C-ITS, so time should be taken to develop the right framework for the EU. A municipality noted that, while the EU might be falling behind some other parts of the world overall, some Member States can be considered to be at the forefront of C-ITS deployment, while another suggested that Europe should look to the USA where they believed that legislation encourages C-ITS to be implemented. A national ministry commented that no C-ITS was yet technically mature, although some were close to being so, although they noted that the maturity of a technology also depended on whether it provided a clear added value to end users. They noted that there were still obstacles in this respect, so appropriate regulation at the EU level was needed.

Those public authorities that disagreed with the Commission’s assessment noted that it was not clear that all manufacturers would introduce C-ITS, that it was not really clear what vehicles can be considered to be fitted with C-ITS or that it was the disproportionate investments needed that was the main barrier to C-ITS deployment.

The NGOs that agreed with the Commission’s assessment, supported their conclusion for various reasons, including that a legal framework was needed: to ensure that the safety benefits of C-ITS were delivered in practice; to reduce implementation barriers; to improve coordination between Member States; and to coordinate the actions of different actors involved in transport. One NGO representing cyclists noted the current uncertainties with respect to the choice of short-range communication technology, while also noting that the draft revision of the EU Regulations on vehicle safety did not mention C-ITS.

Another NGO, representing cyclists, neither agreed nor disagreed with the Commission’s assessment. They questioned the supposition that C-ITS has mainly positive benefits, noting instead that the deployment of C-ITS might make car use more attractive, and thus act counter to many cities’ aim to deliver modal shift away from car use. In this respect, it was suggested that a broadening of C-ITS to include other modes, including bike sharing and apps for more vulnerable modes, should be considered. They also suggested that C-ITS could potentially be a distraction to car drivers, which risked negatively affecting the safety of other road users, whereas some technologies, such as Intelligent Speed Assistance, would clearly have safety benefits and so should be prioritised.

The five citizens who explained their reasons for agreeing with the Commission’s assessment provided similar reasons to those already mentioned by other stakeholders. One citizen underlined that a legal framework was needed to determine all potential liabilities, as well as to address the potential problem of hacking to ensure the safety of users, while another noted that EU level governance was needed to reduce uncertainty for early adopters of C-ITS. Two citizens underlined the need for EU level coordination and standardisation to be able to properly test C-ITS in real-world conditions, with one of these underlining that this would increase European experience and so better inform the EU legislative framework than if the EU adopted standards from elsewhere in the world. Another noted that EU action was necessary as a result of the many actors involved, some of which may not necessarily be acting in the wider interests of society.
One citizen who neither agreed nor disagreed with the Commission’s assessment underlined that the Commission needs to complement market forces in ensuring the deployment of C-ITS. Another suggested that the Commission’s assessment was premature with respect to the maturity of C-ITS technologies.

Similar issues to those raised by other stakeholders were also raised in support of the Commission’s assessment by those who classified themselves as ‘Other’ including:

- the need to avoid fragmented implementation of C-ITS;
- to ensure cross-border interoperability;
- to address a lack of regulatory certainty hindering investment; and
- to improve the availability of data.

One respondent highlighted that it was also important to implement policies that encouraged the purchase and installation of C-ITS on existing vehicles and to enable road operators to distribute the same information through navigation devices and mobile applications.

**E.3.2.3 Q6: From your point of view, how important is the contribution of these drivers to the overall problem? (n=133-136)**

Table E-4 below presents the list of drivers being considered in terms of their importance in contributing to the overall problem (Very important, moderately important, of little importance, not at all important, no opinion/I don’t know).

<table>
<thead>
<tr>
<th>Driver No.</th>
<th>Drivers contributing to the overall C-ITS problem:</th>
<th>Shortened name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6a</td>
<td>The costs of C-ITS remain too high due to the fragmented deployment of separate C-ITS services and ecosystems</td>
<td>‘Costs too high’</td>
</tr>
<tr>
<td>6b</td>
<td>Failure to establish confidence in the cyber-security of C-ITS communications</td>
<td>‘Low cyber-security confidence’</td>
</tr>
<tr>
<td>6c</td>
<td>Public acceptance remains limited due to unclear principles related to privacy and protection of personal data</td>
<td>‘Privacy/data concerns’</td>
</tr>
<tr>
<td>6d</td>
<td>Incompatible communication technologies and frequency spectrum allocation</td>
<td>‘Incompatibilities’</td>
</tr>
<tr>
<td>6e</td>
<td>Uncertain minimum requirements for interoperability of C-ITS services</td>
<td>‘Uncertain interoperability’</td>
</tr>
<tr>
<td>6f</td>
<td>Uncertain minimum requirements for compliance assessment for C-ITS services</td>
<td>‘Uncertain compliance’</td>
</tr>
</tbody>
</table>

A large number of respondents (94-109 out of 133-136 (70-80%)) felt that all drivers presented above were either very important or moderately important in terms of contributing to the current overall problem faced by C-ITS (see Figure E-12). In terms of those considered to be very important, the driver ‘uncertain interoperability’ (6e) was indicated most with 69 responses (51%), compared to just 32 (24%) for ‘uncertain compliance’ (6f). For all drivers, the number of respondents who felt they were of little importance or not at all important was small (20-30; 15-22%).
When responses were analysed by stakeholder group, associations generally showed the highest level of agreement of importance for all drivers discussed (when considering very important and moderately important). For example, when considering the driver ‘low cyber-security confidence’ (6b), 33 out of 36 (92%) associations indicated it was very important or important (see Figure E-13). In general, private company respondents indicated least importance for all drivers (‘of little importance’ and ‘not at all important’) – for example nine out of 39 (23%) when considering low cyber-security confidence.

**Figure E-13: Response on the importance of the driver ‘Failure to establish confidence in the cyber-security of C-ITS communications’ (6b), by stakeholder group**

![Graph showing response on the importance of drivers in contributing to the current overall C-ITS problem](image)
Figure E-14: Response on the importance of the driver ‘Uncertain minimum requirements for compliance assessment for C-ITS services’ (6f), by representing interest

E.3.2.4 Q7: Do you consider that any drivers underlying the problem are missing? Please elaborate (n=102)

One hundred and two respondents had a view on whether there were any drivers missing from the list provided, of which 27 came from associations and 32 were from private companies. A further 24 responses were from public authorities, seven from NGOs and six each were from citizens and those who categorised themselves as ‘other’.

As with the responses to question 5, there were six repeated responses from associations representing distributors of replacement automotive parts and diagnostic tools (and one private company), which identified a driver of the problem being the fact that the current way in which
implementation of C-ITS is being taken forward was based on "individual vehicle manufacturer's proprietary systems", which prevented access to in-vehicle data. Two associations representing insurers also felt that a lack of concrete action to enable access to in-vehicle data was a major factor preventing the deployment of C-ITS.

From the perspective of a vehicle manufacturers’ association (and two manufacturers), a missing driver was the fact that different road authorities made different technology choices for roadside infrastructure, while they also processed and qualified differently the data that they received.

A number of associations took a user perspective. Two associations representing consumers noted that there was a lack of buy-in from citizens and that user needs were not being properly addressed, while also noting, as did another similar association, that a clear case of the benefits of C-ITS was not being made to potential users. Related to this, a city network noted that a business case and the business model were missing for urban areas. An association representing telecommunications interests also noted that a lack of public demand, due to a lack of familiarity with C-ITS and their advantages, should be considered to be a driver.

The financing and cost of C-ITS applications was noted by a number of associations. An association representing logistics interests believed that there was limited support from public investment, while another representing road operators argued that was no reliable launch strategies to justify pre-investment. An association representing digital interests felt that the financing models for the necessary infrastructure investment were unclear. An association representing transport companies felt that the costs in cities in particular was too high, while an association representing road operators believed that the same could be said more generally: both believed that the high costs were more problematic as a result of the limited benefits of C-ITS. The latter also noted that the interaction of C-ITS with existing processes and systems, including electronic toll collection, needed to be considered.

Other issues raised were a lack of clarity around insurance and liability (from a consumer group) and a lack of cooperation between actors (from an association of road operating companies). An association representing ITS interests took this argument further, arguing that competition law prevents the necessary cooperation between C-ITS manufacturers in the course of the development of C-ITS. An association representing public transport operators underlined that – in contrast to the current debate – public transport should be the backbone of any C-ITS deployment plan, as it should be implemented in a way that delivers wider transport policy targets, particularly in urban areas. Otherwise, the interest in C-ITS in urban areas will be limited. An association representing telecommunications providers, and a private company argued that the "uncertain minimum requirements for interoperability" was not a driver of a slow and fragmented C-ITS deployment, rather that a requirement to have mutual interoperability would risk slowing down C-ITS deployment. Consequently, any interoperability requirement should focus on applications.

Issues raised by private companies were similar to those mentioned by associations. Two vehicle rental services company argued that an inability to access in-vehicle data reduced their ability to improve their customers’ experience and to facilitate their use of the rental car. Another company noted that there was no regulatory framework to access connected car data for the aftermarket, and that the solutions being offered by manufacturers to address this did not allow fair and reasonable access. A supplier noted that fragmentation was not acceptable to industry, as it would increase costs and reduce the possibility of providing a good service to users in all Member States, while another noted that a lack of infrastructure enabled for C-ITS was an issue, together with the fact that infrastructure often used different technologies.

Public acceptance linked to the tangible benefits people can derive from C-ITS was considered an issue by a supplier. Another supplier was still not convinced of the need for C-ITS, while a telecommunications provider suggested that there were no clear benefits of C-ITS to road users.

Costs and finance were raised by a number of companies. A vehicle manufacturer noted that capital expenditure would be higher if two technologies – ITS G5/DSRC and LTE V2 – were proposed to address the ‘incompatible communications technologies’ driver. Another manufacturer questioned how fast cities and municipalities would be able to install the technology needed in their infrastructure. One supplier noted the high cost of the roadside infrastructure that was needed, while another noted that it was mainly higher level authorities that had committed funds to C-ITS implementation to date. A consultancy stated that they did not agree with the premise of the question, as the high costs of some C-ITS solutions was a good reason not to use them. An ITS provider questioned the commitment and
knowledge of public authorities. A lack of a business case for manufacturers, particularly in relation to safety applications, was noted as a barrier by four suppliers, while two companies also noted that more consideration of the potential of smartphone-based applications would be useful, as demonstrated in the NordicWay project.

A supplier noted that there was an imbalance between the social benefits of C-ITS and commercial interest, adding that a standardised interface for back-end exchanges was also needed to ensure their compatibility. One company noted that other emerging mobility solutions, including e-mobility, should be considered in the development of the C-ITS policy framework in order to ensure a ‘future-proof’ C-ITS environment.

A couple of companies commented on the use of different frequency bands. A telecommunications provider noted that the ‘Ku’ band was used for providing connectivity to cars, as well as for many other applications. They wanted to ensure that all satellite applications were able to operate in the ‘Ku’ band (in particular the 14.0-14.5 GHz band) and to consider a license exemption and free circulation for satellite earth stations for connected cars in this band. There would then be a natural phase out of the remaining fixed service links in the 14.25-14.5 GHz band. A supplier argued that the deployment of C-ITS should not be jeopardised by harmful interference from other technologies and that technological neutrality cannot be an overriding concern if safety was put at risk.

Respondents from public authorities raised similar issues to other respondents. A repeated response from two authorities (and a citizen) was that existing transport laws and regulations in Member States were not open to the possibilities offered by C-ITS. Other issues raised included:

- a lack of transparency as to what C-ITS are being developed by manufacturers (four times),
- (uncertainty about) the cost of the infrastructure needed (three times), and
- a lack of clear strategies at the local level (three times).

The inability to generate the data needed at the local level, a lack of a coordinated concept for implementation between the various participants and a lack of information about C-ITS performance were all raised by a couple of public authorities. Other issues raised by a single authority were:

- a lack of a business model,
- the need to clarify liability issues in the event of a technical malfunction leading to an accident, and
- the poor quality of the user interface for existing applications.

A national ministry noted that there was a need for further research into how users responded to C-ITS when it was provided as an information service in order to understand its wider impacts. They also noted that it was still not clear whether and how the necessary investments in infrastructure would be made by public authorities.

A couple of respondents from public authorities commented on the ‘incompatible communication technologies’ driver. One noted that as long as the responsibility for generating and distributing safety-related C-ITS services lay with road authorities, the latter will decide which technology to use. Another noted that if the radio spectrum frequency used was in a different band, e.g. 800 MHz, the distances between base stations could be increased, thus reducing costs. In addition, two public authorities noted that the debate about different communication technology was inhibiting deployment.

Various missing drivers were proposed by NGO respondents. These included a lack of consensus amongst the various actors (infrastructure owners, vehicle manufacturers and telecommunications providers) about who will carry the costs, an unwillingness of individual manufacturers to share their data with each other, a lack of public acceptance as a result of a lack of trust and willingness to give control to others and a lack of awareness about C-ITS more generally. One NGO commented that there needed to be a clear interest in C-ITS from public authorities and that if C-ITS did not help authorities to meet their wider policy objectives, it would be difficult for them to justify spending the necessary money. In this respect, it was argued that Intelligent Speed Assistance should be a priority while the benefits and uses of smartphones should not be overlooked. It was also noted by one NGO respondent that the responses to the various questions about drivers was dependent on which C-ITS was being considered, as personal data was not a problem if a user was receiving data from roadside infrastructure.
The potential missing drivers mentioned by *citizens* included a lack of business cases and a lack of agreement amongst different stakeholders. One noted that testing was important to support the establishment of procedures and requirements for C-ITS more generally, while another argued that the mainstream technological solution (i.e. 802.11p) was becoming obsolete as a result of the development of cellular technologies. Another noted that most Day 1 services were agnostic to the way data was received and processed and that they could be deployed with existing IP-based communication networks.

Responses from those categorising themselves as ‘Other’ noted the need for public transport to be explicitly taken into account in the deployment of C-ITS and the lack of a business case/model for C-ITS that addressed specific mobility problems that would bring benefits for all stakeholders involved. Another respondent listed issues that were important for road operators and road authorities, which included the ability of the sector to implement long-term plans, the correct assignment of frequencies to avoid interference with existing systems (e.g. toll systems), liability in the event of an accident and uncertainties relating to technology choice. Their concern with the latter was that the speed of the development of alternatives to the existing mainstream technologies might render the latter obsolete.

Another respondent noted that the uncertainties with respect to data in general, and to vehicle data in particular, from road and traffic managers and operators, was an issue.

**E.3.2.5 Q8. The Commission has established the following objectives for this initiative. From your point of view, how important is it to achieve these objectives? (n=133-136)**

Table E-5 below presents the objectives being considered for the initiative in terms of their importance of being achieved (Absolutely essential, very important, moderately important, of little importance, not at all important, no opinion/I don’t know).

**Table E-5: Objectives considered for Question 8**

<table>
<thead>
<tr>
<th>Objective No</th>
<th>Objectives considered for this initiative:</th>
<th>Shortened name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8a</td>
<td>Ensure continuous availability of C-ITS services for users across the EU, by clearly defining a set of priority C-ITS services</td>
<td>‘Continuous availability’</td>
</tr>
<tr>
<td>8b</td>
<td>Ensure security of C-ITS communications by establishing common rules</td>
<td>‘Security’</td>
</tr>
<tr>
<td>8c</td>
<td>Ensure the practical application of Data Protection in the area of C-ITS</td>
<td>‘Data protection’</td>
</tr>
<tr>
<td>8d</td>
<td>Ensure a forward-looking hybrid communication approach (combining complementary communication technologies, e.g. WiFi and cellular)</td>
<td>‘Forward-looking comms’</td>
</tr>
<tr>
<td>8e</td>
<td>Ensure interoperability of C-ITS services by establishing common rules</td>
<td>‘Interoperability’</td>
</tr>
<tr>
<td>8f</td>
<td>Ensure seamless deployment of C-ITS service by establishing a compliance assessment framework (which allows services to be checked against EU-wide requirements)</td>
<td>‘Seamless deployment framework’</td>
</tr>
</tbody>
</table>

As shown in Figure E-15, a large proportion of respondents stated that they felt all objectives were absolutely essential or very important – Ensuring ‘security’ (8b) and ‘interoperability’ (8e) were considered the most important (122 out of 136 (90%) and 116 out of 134 (87%) respectively). The least important objective considered was ensuring ‘forward-looking communications’ (8d) however 91 out of 133 (68%) respondents still indicated it absolutely essential or very important. The number of respondents who had no opinion/did not know was small except for ‘forward looking comms’ for which another 15 respondents (11%) stated this. The objectives ‘continuous availability’ (8a), ‘forward-looking coms’ (8d) and ‘seamless deployment framework’ (8f) received the least support in terms of little importance and not at all important responses, yet this number was very small (12, 12 and 10 out of 134,133 and 135 respectively).
When analysed by stakeholder groups, private company respondents in general indicated most support for objectives being achieved. For example, the most favoured objective of ensuring ‘security’ (8b) (see Figure E-16) had 36 out of 39 respondents (92%) indicating it absolutely essential or very important. This was the case for all objectives except the least favoured ‘forward-looking comms’ (8d) for which the amount of association respondents indicating absolutely essential or very important was 2% higher. The stakeholder that had at least one negative (little/no importance) response for all objectives was public authorities.
When analysed by representing interest, clear consensus was seen with all drivers. For example, when looking at the most favoured objective in terms of ensuring interoperability of C-ITS services by establishing common rules (8e) (Figure E-17), at least 88% of respondents from all interest groups felt it moderately important or higher that this objective was achieved. Several respondents representing vehicle and equipment manufacturers/suppliers/repairs and societal/consumer rights (four out of 30 and three out of 11 respectively) felt the objective ‘forward-looking hybrid communication’ (8d) was of little importance or not important at all, along with several regional/local public authorities (three out of 14) for the objective of ‘ensuring continuous availability’ (8a), however these amounts were not considered significant.
E.3.2.6 Q9. Please elaborate on your answers to the previous question. Do you consider that any objectives are missing? (n=97)

Of the ninety seven respondents who elaborated on their response to question 8, 28 were from associations and 27 were from companies. A further twenty one responses were from representatives of public authorities, eight were from NGOs and five were from citizens, with the remaining eight coming from those who categorised themselves as ‘other’.
A number of respondents from associations made the case for additional legislative action. A repeated response from five associations representing distributors of replacement automotive parts and diagnostic tools (and one private company) called for C-ITS to be regarded as an integrated part of the vehicle, not as a separate IT element. Consequently, it was important that all of a vehicle’s hardware and software should be regulated and tested as one unit. Two associations (and a private company) concerned with vehicle inspection underlined the need for rules and transparent procedures to test the whole system for both type approval and roadworthiness testing. They also highlighted that the relevant transport infrastructure should be “consistently and permanently” operational.

An association representing garage equipment suppliers called for the interoperable requirements of a vehicle platform to be standardised through CEN and be part of vehicle type approval requirements. Two associations representing insurers provided similar responses calling for an additional objective to establish a legal framework to ensure in-vehicle access to vehicle data. They believed that this was needed to ensure that consumers were in control of who has access to their in-vehicle data, as well as to ensure that there was a level playing field for data-based service providers. An association representing consumers called for an enhancement of education and training practices for drivers and noted (along with a similar association) that it was important for the Commission to ensure that consumer rights were protected. However, they both argued that if industry did not see a business case for a particular C-ITS application the Commission should not intervene.

A number of respondents highlighted the importance of a hybrid approach to communication. An association representing vehicle manufacturers (and a manufacturer) believed that such an approach was essential and that the approach was being handled appropriately by the Commission. They also believed that common rules should not be established by regulation, but by the efforts of industry. Furthermore, they noted that due consideration needed to be given – e.g. in CEPT/ETSI – to ensuring that technologies such as LTE-V did not interfere in a harmful way with other technologies in the 5.9 GHz radio frequency spectrum. An association representing road operators underlined that their members needed to be able to procure C-ITS that functioned well using different communication technologies. Another similar association also supported a hybrid approach, but noted that this needed to be dynamic in order to take account of the different degrees of maturity of different technologies.

An association representing telecommunications interests also underlined the need for a hybrid approach to communications. Further, they noted that the standards and established working practices of the telecommunications industry relating to the ‘operational securitisation and efficient deployment’ should be taken as an important point of reference in this respect. They also underlined that the development of the compliance assessment framework should be integrated with the fulfilment of all of the other objectives. Another association representing telecommunications interests (and a similar response from a private company) believed that certain objectives set out in Annex II of the ITS Directive should be prioritised by the Commission. They noted that no technology should be seen to be the incumbent; instead the outcome that should be focused on was that which was cost-efficient. They believed that such an outcome would be delivered where both C-V2X and IEEE 802.11p co-existed in the 5.9 GHz radio spectrum frequency band. Another principle that they considered should be applied was proportionality, and so C-V2X should not be required to be interoperable and backwards compatible with IEEE 802.11p.

The importance of engaging and informing consumers was noted by a number of respondents. Two associations (and a private company) concerned with vehicle inspection underlined that consumers needed to understand the how data was used, and that the training and education of drivers was crucial as vehicles became more automated. They noted that work was ongoing in this area, which should not be duplicated, so reference should be made in the C-ITS policy framework to both the GDPR and the e-privacy Regulation. An association representing ITS interests and another representing consumers noted that data protection and interoperability were particularly important, although an association representing traders in automotive parts believed that the former was not very relevant for C-ITS.

There were a number of responses relating to infrastructure, and its financing. An association representing road surfacing interests noted that it was important to identify what infrastructure was needed for different applications and to decide who should be responsible for its provision and maintenance. An association representing consumers underlined that it was important to ensure that public authorities invested in infrastructure, while an association representing automotive suppliers underlined that it was important to ensure that public-private investments were made. An association
representing the railway industry noted that C-ITS should include communications at the interface between road and railways, especially at level crossings.

An additional comment from a consumers’ organisation called for the ‘upgradability’ of the C-ITS components of vehicles to be mandatory, as the lifetime of cars is typically 10 years or more. Two associations representing transport operators underlined that they needed to ensure the continuity of their services, so that private technology providers must also be able to provide operators with a certain level of service, particularly if safety would otherwise be at risk. An association representing road operating companies called for the choice of the technologies to be deployed to be left to the market, while an association representing similar interests noted, in defining the appropriate roles and responsibility with respect to C-ITS, that the role of the concessionaire, as an active manager of the roads, should not be lost.

A number of respondents from private companies also called for the development of additional legislative action. A company responsible for repair and replacing vehicle parts called for a clear and fair legal framework to ensure that the aftermarket can access connected car data. The need for a binding legal framework to ensure access to in-vehicle data – in readable and interoperable format – to all market operators was also raised by a car rental company. A supplier noted that the approach taken to the C-ITS corridors was a good way of avoiding the ‘chicken-or-egg’ problem and that a mandate should be considered.

Several private companies also raised the debate between ITS G5 and LTE V2X. A supplier noted that clarifying the role of these two was important, as there should not be competing technologies from the first day. Another supplier was critical of the ‘push from the cellular industry’ to bring an unproven technology into the same radio spectrum frequency band in which stakeholders were deploying ITS-G5, and was concerned that this would affect the deployment of the latter and so not deliver its potential benefits. A vehicle manufacturer noted that feasibility tests needed to be undertaken of the potential of LTE V2X to co-exist in the 5.9 GHz frequency band, or for it be allocated a new frequency band in order to avoid interference with ITS G5. Another vehicle manufacturer called for the hybrid communication approach to allow for both Wi-Fi cellular and C-V2X cellular, while noting that interoperability between these was not possible. A third manufacturer called for ‘co-existence concepts’ for ITS-G5 and LTE-V to be developed. An ITS service provider noted that a hybrid communication approach was essential, particularly as it was hard to reconcile the ‘V2X aspect’ with GDPR and e-privacy. A telecommunication provider agreed with all of the objectives identified, but called for the Commission to recognise satellite communications as a necessary element when considering a hybrid communication approach.

A vehicle manufacturer noted that there was no level playing field between road authorities in terms of the technology that they were choosing and the way in which they processed and qualified the data that they received. A transport operator called for transport operators to be directly involved in defining the framework for C-ITS.

Proposals for additional potential objectives for the development of a policy framework on C-ITS included:

- Set technology neutral standards; build on existing standards; create a good balance between physical and digital infrastructure; and ensure redundancy when higher levels of automation are possible (from a vehicle supplier).
- Digitisation of road infrastructure (another supplier).
- Establish a clear common position on liability (for safety-related devices); and ensure that the initial benefits of C-ITS are focused on sustainable modes (a consultancy).
- Ensure affordability of C-ITS for end users; ensure that developments in connected vehicles lead to the development of autonomous vehicles; make the activation of C-ITS the default setting; and ensure a level playing field to avoid market dominance (with reference to C-V2X in particular) (another supplier).

Some respondents did not agree with the need for EU level action in all areas. A vehicle manufacturer argued that service harmonisation and hybrid communication were already being addressed so that there was no need for legislation in these areas. An equipment supplier noted that, while standardisation was needed, it should be left to the market to decide which C-ITS services were important. A consultancy argued that the role of the EU should be on ensuring an equal level of protection for citizens, not on defining services or determining technical solutions. A vehicle supplier proposed that legislation
was not able to develop fast enough, so industry self-certification based on a compliance framework was preferable.

From the perspective of **public authority** respondents, some objectives that were missing from the list provided in the online public consultation were:

- Provide clear guidance on the responsibility of public authorities when it comes to C-ITS service generation and C-ITS service provision.
- Create a governance structure for government-private consortia.
- Ensure that vehicle manufacturers deploy C-ITS technology.
- Increase public support through communication.
- Ensure cooperation from road authorities.
- Ensure that C-ITS services offer improved functionality that keeps increasing as the development of automatic driving progresses.

Another respondent noted that it was important to clarify the ownership rights of different types of data. A national authority noted that it was important to choose use cases that were adapted to particular networks or areas. A municipality noted that they needed long-term investment security, particularly in relation to the communications technology used, while another noted that investments in C-ITS were often difficult to justify politically as a result of a lack of a binding policy framework. A respondent underlined the importance of giving consideration to centralised communication, noting that many municipalities were already able to communicate directly with vehicle manufacturers.

A regional authority noted that insufficient attention was being paid to the need for barrier-free communication for drivers, while it was also important to communicate the ‘non-availability’ of content to remove the potential for adverse consequences as a result of this information being assumed to be available. Another noted that the challenge for implementation of C-ITS was to ensure that a service was available anytime, anywhere, which made it challenging from the perspective of the content of the services. While noting that the continuity of C-ITS should be guaranteed, a national ministry noted that there should be sufficient flexibility to allow the market to decide which services have the highest value to the end user. Another national ministry noted that, at this early point in the development of C-ITS, it was not necessary for the legislative framework to search for the perfect solution, as this risked slowing down development and deployment.

A national transport authority, while agreeing that all of the Commission’s stated objectives were relevant for C-ITS provided by public authorities, was not convinced that they all applied where such services were provided by commercial companies, as the latter would not be on the market long if they did not comply with some of the objectives. A national roads office argued that, while the compliance assessment framework should be set up in accordance with general legal requirements, the responsibility for undertaking the assessment should lie with industry, with public authorities intervening only if the legal requirements were not followed.

Several **NGO respondents** highlighted the way in which C-ITS needed to take account of, or even involve, cyclists and pedestrians. An NGO representing cyclists called for the European Statement of Principles on Human Machine Interface to be updated to take account of C-ITS. They also noted that driver training and education in relation to C-ITS was important, and that this should be mandated as part of the qualifications of professional drivers. They repeated a call made in response to an earlier question that the introduction of Intelligent Speed Assistance (ISA) in new vehicles should be prioritised, while noting that speed mapping should be coordinated to help make ISA a reality. They also argued that cellular technology made it easier to include pedestrians and cyclists, as did a group representing business. A consumer group argued that it was essential that C-ITS was only used to improve safety and driving efficiency, and never for other purposes.

More generally, a safety NGO noted that using cellular technologies was a potentially good means of delivering an early mass take-up of C-ITS services. They also called for a roll-out plan for C-ITS services, rather than trying to roll these out everywhere at the same time, with an initial focus on the strategic road network. A group representing road users called for a global agreement, rather than just an EU agreement, on the relevant requirements and rules.

A response from a **citizen** proposed that the focus of the initial deployment should be on the parts of cities and on the main corridors where it makes most sense to invest and that data would be best made available on telematics or smartphones using the best available data channel. Another noted that
access to safety and traffic management-related data should be ensured, while a third underlined the need to ensure the acceptability of C-ITS by citizens. They noted that a targeted advertising campaign would be important in this respect, and that the Commission was an appropriate organisation to undertake such a campaign.

Responses from those who classified themselves as ‘Other’, generally explicitly supported the objectives stated in the online public consultation. One suggested that, while security, privacy and data protection were important, there was perhaps too much emphasis on these elements, while another noted that public awareness of data protection was only moderate. It was also noted that while continuous availability was important, it was not essential.

**E.3.2.7 Q10. From your point of view, how important is it to achieve these objectives through action at the EU level (as opposed to action only at the national level or international standardisation)? (n=132-135)**

Table E-6 below presents the objectives being considered through action at the EU level, as opposed to action only at national level or international standardisation (Absolutely essential, very important, moderately important, of little importance, not at all important, no opinion/I don't know).

<table>
<thead>
<tr>
<th>Objective No</th>
<th>Objectives considered through action at EU level:</th>
<th>Shortened name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10a</td>
<td>Ensure continuous availability of C-ITS services for users across the EU, by clearly defining a set of priority C-ITS services</td>
<td>‘Continuous availability’</td>
</tr>
<tr>
<td>10b</td>
<td>Ensure security of C-ITS communications by establishing common rules</td>
<td>‘Security’</td>
</tr>
<tr>
<td>10c</td>
<td>Ensure the practical application of Data Protection in the area of C-ITS</td>
<td>‘Data protection’</td>
</tr>
<tr>
<td>10d</td>
<td>Ensure a forward-looking hybrid communication approach (combining complementary communication technologies, e.g. WiFi and cellular)</td>
<td>‘Forward-looking comms’</td>
</tr>
<tr>
<td>10e</td>
<td>Ensure interoperability of C-ITS services by establishing common rules</td>
<td>‘Interoperability’</td>
</tr>
<tr>
<td>10f</td>
<td>Ensure seamless deployment of C-ITS service by establishing a compliance assessment framework (which allows services to be checked against EU-wide requirements)</td>
<td>‘Seamless deployment framework’</td>
</tr>
</tbody>
</table>

A large proportion of respondents (90-116 out of 132-135 (68-86%)) indicated that it was absolutely essential or very important for all objectives to be achieved at EU level as opposed to only at national level or international standardisation (see Figure E-18). The objective ensuring interoperability (10e) had the most respondents who felt it absolutely essential (82 out of 134; 61%) compared to the objective ‘seamless deployment framework’ (10f) (where only 49 out of 133 (37%) stated this. The number of respondents who had no opinion/did not know was very small, except for the objective ‘forward-looking comms’ (10d) where 14 out of 132 (11%) stated this. The number of respondents who felt the objectives were of little importance or not important at all was also small (between four and 13 out of 132-135 (3-10%).)
When responses were analysed by stakeholder group, consensus between the stakeholders was identified in most areas. There was an approximately identical split within each stakeholder group when looking at the objectives ‘continuous availability’ (10a) ‘data protection’ (10b) ‘forward-looking comms’ (10d) and ‘interoperability’ (10e) (see Figure E-19). For example, at least 74% of respondents felt it absolutely essential or very important to achieve the objective of ensuring interoperability at EU level. Citizen respondents felt all objectives were absolutely essential or very important (at least 63%) except for when considering the objective ‘seamless deployment framework’ (10f) for which only 27% did. A very small number of respondents across all stakeholders indicated the objectives were of little importance or not at all familiar (one-three), but this was not considered significant.

Figure E-19: Response on the importance of the objective ‘Ensure interoperability of C-ITS services by establishing common rules’ (10e) being achieved at EU level (as opposed to action only at national level or international standardisation), by stakeholder group
When responses were analysed by representing interest¹, consensus was again seen in most areas. A large proportion of respondents from all interests felt the importance of objectives being achieved at EU level was either absolutely essential or very important. For example, when looking at the least favoured objective ‘Seamless deployment framework’ (10f)(Figure E-20), at least 50% of respondents from all interest groups stated this (aside from the unknown group). For the objective of ‘continuous availability’ however, the amount of respondents stating it absolutely essential varied, from 15 out of 30 (50%) from those representing vehicle and equipment manufacturers.suppliers.repairs and 11 out of 15 (73%) others, to only one out of seven (14%) ITS service providers. A small number of respondents across all interest groups except automotive replacement part associations indicated the objectives were of little importance or not at all familiar, but this was not considered significant (one-three).
E.3.2.8 Q11. Please elaborate on your answers to the previous question (n=78)

Of the seventy eight respondents who elaborated on their answers to Question 10, 26 were from associations and 23 were from private companies. Of the remainder, 15 were from public authorities, seven from NGOs and three from citizens, with four responses being provided by respondents that had categorised themselves as ‘other’.

When elaborating their responses to Question 10, many respondents from associations underlined the need for EU action on C-ITS generally. A repeated response from six associations representing distributors of replacement automotive parts and diagnostic tools (and one private company) argued
that only an EU level approach would ensure that C-ITS operates in a fully effective and beneficial way. An association representing road surfacing interests underlined that EU action was necessary as a result of the need for all elements of C-ITS systems to be able to interact across modes and borders. Two associations (and a company) concerned with vehicle inspections argued for EU rules to promote a common European transport policy for automated and, in the future, autonomous vehicles and to provide legal certainty for drivers. An association representing vehicle manufacturers (and two manufacturers) stated that an EU framework was necessary to guarantee cross-border services. An association representing road operators supported EU action as municipal road operators needed a reliable, long-term basis in which to invest in C-ITS. General support for an EU level approach was also given by two associations representing traders of automotive parts, an association representing logistics interests and an association representing ITS interests.

Other respondents from associations underlined the need for EU action with respect to particular objectives. Two associations representing insurers provided similar responses arguing that security, data protection, ensuring a hybrid communication approach and interoperability of C-ITS services can only be regulated at EU level as a result of the cross-border nature of road traffic. An association representing the bicycle industry (and a private company) underlined the need for EU action to address interoperability and to ensure a hybrid approach to communications technology. An association representing public transport operators supported the need for EU action on data protection and security, but noted that in order to deliver the other objectives, close cooperation was needed between the EU and technology providers, manufacturers and end-users of the technology.

An association representing transport companies noted that it was important to develop different priority use cases for cities than for motorways, as the two environments were very different. An association representing railway interests reiterated a response to a previous question that C-ITS should include communications at the interface between roads and railways, especially at level crossings.

Some associations representing telecommunications interests were less supportive of EU action. One supported global action to address the stated objectives, as the automotive industry was a global industry. They further argued that cellular V2X was a ‘future proof’ technology that was developing rapidly and was readily adaptable to new use cases, which prevented it from becoming obsolete. Another argued that, while achieving continuous availability and security of C-ITS merited involvement by the EU institutions, it did not believe that such institutions should be involved in specifying technical solutions or in designating essential functional requirements, as these were better left to international standardisation processes. A third (along with a private company) argued that the proposed hybrid communication approach could not be considered to represent a ‘forward looking approach’, as a result of its technology coverage. Instead, they argued that interoperability of these should be left to the ongoing processes involving ETSI and CEPT to resolve any issues caused by the co-existence of different technologies in the ITS band of the radio frequency spectrum.

Many respondents from private companies were supportive of EU level action generally, or in specific areas. Two suppliers noted that fragmentation needed to be avoided in order to reduce costs and accelerate deployment. One of these also noted that this would help to increase customer acceptance while the other noted that the EU should provide a minimum set of services, as was being proposed in the US. The latter also reiterated their criticism of the cellular industry in trying to bring forward, what they considered to be an unproven technology, into the radio spectrum frequency band used by ITS safety applications. Another supplier underlined the need for backward compatibility with ITS-G5 and proposed that the EU cooperate with the US in this respect. An ITS service provider noted that EU action could ensure long-term viability and economies of scale, while a telecommunications provider noted that interoperability was important as national action would not address cross-border needs.

A supplier expressed the hope that European standards could even be adopted internationally, while an ITS service provider noted that after harmonisation, uniformity was important for achieving a critical mass. In supporting the need for EU action to deliver the continuous availability of C-ITS for users across the EU, a telecommunications provider underlined the need to recognise the potential role of satellite communications technology in providing the necessary mix of communications technology.

A car rental company highlighted interoperability and security as the two most important elements of a common EU approach, while a supplier highlighted individual protection. A research network noted that the implementation of C-ITS should be seen as a step towards cooperative automated driving, which could be assisted through co-financing the implementation of C-ITS. Reiterating their responses to previous questions, a car rental company and a company involved in the repair and replacing of vehicle
parts underlined the need for EU action to develop a binding legal framework to ensure fair and interoperable access to in-vehicle data for all market operators in order to protect consumer rights and to promote innovation.

Other private companies had some concerns. A vehicle manufacturer called for a technology neutral approach, including one that allowed direct communication via LTE-V or Wi-Fi. They noted that compatibility between C-V2X and Wi-Fi was technically not possible, but argued that it should be left to market forces to decide which technology was best. A telecommunications provider also argued for a technology neutral approach as technology was developing fast, so a too-detailed legislative framework risked locking-in outdated technology and thus risked not delivering the ambition of Europe to lead the world in this area.

Public authority respondents from municipalities who elaborated on their response to Question 10 were generally supportive of EU action, whereas respondents from Member State ministries were more cautious. One regional administration noted that technology was global, so national action would be insufficient, so EU action was better as global action was unlikely. A repeated response from two municipalities noted that EU action was needed to provide a long-term reliable foundation for investment, while another supported EU action to enforce the interoperability of technology. Another noted that EU action was needed as ITS did not stop at national borders. One municipality underlined that the EU should be seen as the platform, and not the authority, where all the national and regional knowledge comes together. Another noted that hybrid communication was perhaps a temporary necessity or compromise, as the future of communications technology was highly uncertain. One national authority noted that all of the proposed actions were needed to avoid fragmentation. Additionally, they suggested that experience with road tolling underlined that standards on their own were not sufficient; harmonised specifications were essential.

A response from a national authority suggested that the compliance assessment should focus on security and interoperability and noted that the definition of priority services was not synonymous with deploying these everywhere. A national ministry noted that there were still many uncertainties about the exact measures that needed to be undertaken, while another national ministry noted that the EU should be careful not to over-regulate at this stage. A national transport administration noted that any response to Question 10 depended on the services being considered and who was providing them.

NGO respondents who elaborated on their responses to Question 10 generally supported EU action, as otherwise C-ITS would not operate to its potential. One highlighted that EU action was better than national and international action, as the former would risk fragmentation and the latter would take too long. Another highlighted that the EU should not do research and development and not favour certain approaches over others.

One citizen who responded was not convinced of the need for the definition of a clearer set of priority services, arguing that this risked ignoring potential innovative services. They also underlined that common rules that bound-in a particular technology should be avoided, while supporting action on security, data protection and hybrid communication. Another citizen underlined that, even though some Member States were lagging behind others in terms of implementing C-ITS, these should not be allowed to impose less stringent standards, as this would risk undermining trust in C-ITS.

One of those respondents categorising themselves as ‘Other’ noted that many of the objectives were already being addressed at the EU level in the work of the C-ITS Platform and the C-Roads projects. Another warned against building a European policy framework using a top-down model, underlining that a bottom up approach was more important.

**E.3.2.9 Q12. To achieve the above objectives, different types of action could be foreseen (n=123-133)**

Q12.a. For the objective "Ensure continuous availability of C-ITS services for users across the EU, by clearly defining a set of priority C-ITS services", please rank the types of action from most appropriate (1) to least appropriate (3) to achieve the objective.

Figure E-21 highlights that responses to the objective "ensure continuous availability of C-ITS services for users across the EU, by clearly defining a set of priority C-ITS services" were fairly mixed. However, the action of legally binding EU specifications on C-ITS had most support (55 out of 133 responses; 41%) compared to 43 out of 129 (33%) for soft legislation and 35 out of 126 (28%) for an industry-led approach. Even though soft legislation did not receive greatest support, it was the action that received

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the least number of least appropriate responses (18 out of 129; 14%). In comparison, the action of industry-led approach received the least support, with 59 out of 126 (47%) least appropriate responses.

Figure E-21: Ranked response to the appropriate action for the objective “Ensure continuous availability of C-ITS services for users across the EU, by clearly defining a set of priority C-ITS services”

When responses were analysed by representing interest¹ as shown in Table E-7, respondents with interests in vehicle and equipment manufacturers/suppliers/repairs, regional or local public authorities, societal interests/consumer rights and automotive replacement part associations were mostly in favour of legally binding EU specifications (50%, 50%, 55% and 100% respectively). Respondents with interests in automotive replacement parts were strongly in favour of legally binding action. All other interests had respondents split more equally between the three actions.

Table E-7: Number of first choice (rank 1) responses for the objective “Ensure continuous availability of C-ITS services for users across the EU, by clearly defining a set of priority C-ITS services”, by representing interest

<table>
<thead>
<tr>
<th>Stakeholder Category</th>
<th>Industry-led</th>
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<th>Legally binding</th>
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<td>Vehicle and equipment manufacturers/suppliers/repairs</td>
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<td>National Public Authorities</td>
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<td>Societal interests and/or consumer rights</td>
<td>3</td>
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<td>6</td>
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<td>Research/Academia/Consultancies</td>
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<td>ITS service providers</td>
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<tr>
<td>Telecommunications providers</td>
<td>3</td>
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<tr>
<td>Associations representing automotive replacement parts</td>
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<td>Other</td>
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</table>

Q12.b. For the objective “Ensure security of C-ITS communications by establishing common rules”, please rank the types of action from most appropriate (1) to least appropriate (3) to achieve the objective.

Figure E-22 shows that the action considered most appropriate for the objective “ensuring security of C-ITS communications by establishing common rules” was having legally binding specifications, where 76 out of 131 respondents (58%) stated this compared to 21-23% for other actions. Soft legislation was the next most supported action, with 84 out of 129 responses (65%) indicating it moderately appropriate.
In comparison, industry-led approach received the least support, with 73 out of 123 respondents (59%) indicating it least appropriate.

Figure E-22: Ranked response to the most appropriate action for the objective “Ensure security of C-ITS communications by establishing common rules”

When responses were analysed by representing interest, as shown in Table E-8, respondents with interests in automotive replacement parts were strongly supportive of legally binding action, where as respondents with interests in ITS service providers were strongly supportive of either industry-led or soft legislation action (43% and 57% respectively). Respondents with research/academia/consultancy interests did not favour soft legislation action for this objective, whilst regional or local public authorities did favour industry-led action. Telecommunications provider and road authority interest had respondents split more equally between the actions.

Table E-8: Number of first choice (rank 1) responses for the objective “Ensure security of C-ITS communications by establishing common rules”, by representing interest

<table>
<thead>
<tr>
<th>Stakeholder Category</th>
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<th>Legally binding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle and equipment manufacturers/suppliers/repairs</td>
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<td>National Public Authorities</td>
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<td>Research/Academia/Consultancies</td>
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<td>ITS service providers</td>
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<td>Associations representing automotive replacement parts</td>
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<td>Road user</td>
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<tr>
<td>Other</td>
<td>3</td>
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</tbody>
</table>

Q12.c. For the objective ”Ensure the practical application of Data Protection in the area of C-ITS”, please rank the types of action from most appropriate (1) to least appropriate (3) to achieve the objective.

Figure E-23 shows that, as in Q12, the most supported action for the objective “ensuring the practical application of Data Protection in the area of C-ITS” was having legally binding specifications, where 80 out of 131 respondents (61%) indicated it most appropriate compared to 14-26% for other actions. Soft legislation was the next most supported action, with 82 out of 129 responses (64%) indicating it
moderately appropriate. In comparison, industry-led action received least support, with 86 out of 126 respondents (68%) stating it as least appropriate.

Figure E-23: Ranked response to the most appropriate action for the objective “Ensure the practical application of Data Protection in the area of C-ITS”

When responses were analysed by representing interest, as shown in Table E-9, respondents representing interests in vehicle and equipment manufacturers/suppliers/repairs, road/transport operators, national public authorities and replacement part associations indicated that legally binding action was the most suited approach to this objective (70%, 67%, 64% and 80% respectively). Respondents with interests in societal/consumer rights and telecommunications and ITS service providers did not favour industry-led action, whilst remaining interests had a more equal split between the actions.

Table E-9: Number of first choice (rank 1) responses for the objective “Ensure the practical application of Data Protection in the area of C-ITS”, by representing interest

<table>
<thead>
<tr>
<th>Stakeholder Category</th>
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<th>Legally binding</th>
</tr>
</thead>
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<td>National Public Authorities</td>
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<tr>
<td>Societal interests and/or consumer rights</td>
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<td>Research/Academia/Consultancies</td>
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<td>ITS service providers</td>
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<td>Telecommunications providers</td>
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<tr>
<td>Associations representing automotive replacement parts</td>
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<td>1</td>
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<tr>
<td>Road user</td>
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<td>0</td>
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</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>4</td>
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</tbody>
</table>

Q12.d. For the objective “Ensure a forward-looking hybrid communication approach”, please rank the types of action from most appropriate (1) to least appropriate (3) to achieve the objective.

Figure E-24 highlights that responses to the objective “ensuring a forward-looking hybrid communication approach” were mixed. Industry-led action received the most support with 52 out of 123 (42%) most appropriate responses, however this also received 48 out of 123 responses (39%) for least appropriate.
Soft legislation was the next most supported action, with 69 out of 126 responses (55%) indicating it moderately appropriate, and this also received the smallest number of least appropriate responses (17 out of 126; 13%). Legally binding specifications was thought to be least suited, with 61 out of 128 (48%) least appropriate responses.

**Figure E-24: Ranked response to the most appropriate action for the objective “Ensure a forward looking hybrid communication approach”**

When analysed by representing interest, as shown in Table E-10, all respondents with interests in ITS service providers felt industry-led action was the best approach. In comparison, all respondents representing interests in replacement parts felt legally binding action was the most appropriate. Respondents with interests in both road/transport operators and telecommunications providers did not favour legally binding action for this objective. The other interest groups had a more even split between the three actions.

**Table E-10: Number of first choice (rank 1) responses for the objective “Ensure a forward-looking hybrid communication approach”, by representing interest**

<table>
<thead>
<tr>
<th>Stakeholder Category</th>
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</tr>
</thead>
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<td>Research/Academia/Consultancies</td>
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<tr>
<td>ITS service providers</td>
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<td>Associations representing automotive replacement parts</td>
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<td>Road authorities</td>
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<tr>
<td>Other</td>
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<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

Q12.e. For the objective “Ensure interoperability of C-ITS services by establishing common rules”, please rank the types of action from most appropriate (1) to least appropriate (3) to achieve the objective.

Figure E-25 highlights that views were mixed, but the action considered most appropriate for the objective “ensuring interoperability of C-ITS services by establishing common rules” was having legally binding specifications, where 66 out of 130 respondents (51%) indicated it most appropriate compared to 21-31% for other actions. However, this action also received 51 out of 130 least appropriate responses also (39%). Soft legislation was the next most supported action, with 73 out of 125 responses
(58%) indicating it moderately appropriate. Industry-led action received least support, with 64 out of 125 respondents (51%) stating it as least appropriate.

Figure E-25: Ranked response to the most appropriate action for the objective “Ensure interoperability of C-ITS services by establishing common rules”

When analysed by representing interest⁴, as shown in Table E-11, respondents with interests in national public authorities, research/academia/consultancy, automotive replacement parts, and other felt legally binding action was the most appropriate (64%, 78%, 100% and 62% respectively). In comparison, all respondents with interests in telecommunications or ITS service providers felt that legally binding action was less appropriate. Additionally, all respondents with interests in regional or local public authorities felt that industry-led action was the least appropriate method. Other interest groups had a more even split across the three actions.

Table E-11: Number of first choice (rank 1) responses for the objective “Ensure interoperability of C-ITS services by establishing common rules”, by representing interest

<table>
<thead>
<tr>
<th>Stakeholder Category</th>
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<th>Soft legislation</th>
<th>Legally binding</th>
</tr>
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<td>Research/Academia/Consultancies</td>
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<td>ITS service providers</td>
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<tr>
<td>Telecommunications providers</td>
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<td>1</td>
<td>0</td>
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<tr>
<td>Associations representing automotive replacement parts</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Road authorities</td>
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<tr>
<td>Road user</td>
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<tr>
<td>Other</td>
<td>3</td>
<td>2</td>
<td>8</td>
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</tbody>
</table>

Q12.f. For the objective "Ensure seamless deployment of C-ITS service by establishing a compliance assessment framework (which allows services to be checked against EU-wide requirements)", please rank the types of action from most appropriate (1) to least appropriate (3) to achieve the objective.

Figure E-26 shows that views were mixed. The action considered most appropriate for the objective "ensuring seamless deployment of C-ITS service by establishing a compliance assessment framework" was having legally binding specifications, where 56 out of 131 respondents (43%) indicated it most appropriate. However, this was closely followed by soft legislation action with 50 out of 126 respondents
In fact, this action also received 64 out of 126 moderately appropriate responses (51%) and the smallest number of least appropriate responses (12 out of 126; 10%) (compared to legally binding action with 50 out of 131 (38%) least appropriate responses). In comparison, industry-led action received the least support, with 68 out of 126 (54%) least appropriate responses.

Figure E-26: Ranked response to the most appropriate action for the objective “Ensure seamless deployment of C-ITS service by establishing a compliance assessment framework (which allows services to be checked against EU-wide requirements)”

When analysed by representing interest\(^1\), as shown in Table E-12, respondents representing interests in societal/consumer rights, research/academia/consultancies, automotive replacement parts and other felt that legally binding action was the most appropriate for this objective (55%, 67%, 100% and 58% respectively). In comparison, respondents with interests in road/transport operators and national public authorities stated that soft legislation was the most appropriate (64% and 57% respectively). Other interest groups had a more even split across the three actions.

Table E-12: Number of first choice (rank 1) responses for the objective “Ensure seamless deployment of C-ITS service by establishing a compliance assessment framework”, by representing interest

<table>
<thead>
<tr>
<th>Stakeholder Category</th>
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<th>Legally binding</th>
</tr>
</thead>
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<td>ITS service providers</td>
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<td>Other</td>
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</tbody>
</table>

**E.3.2.10 Q13. Please elaborate on your answers to the previous question. In particular, if you favour EU action, please indicate what this needs to cover and what form it should take. Please also indicate if you think**
other (types of) action(s) should be considered to achieve the objectives (n=96)

Ninety six respondents elaborated on their responses to Question 12. Twenty nine of these were from associations, twenty eight from companies, twenty one from public authorities, eight from NGOs and six from citizens. The remaining five came from those who categorised themselves as ‘other’.

When elaborating on their answers to Question 12, a number of respondents from associations simply underlined or reiterated their support for EU action for various reasons. Two associations representing automotive importers and traders suggested that the market would not deliver the specified goals, so binding specifications were needed. A consumers’ organisation argued that binding EU rules were the only way of creating EU-wide legal certainty and clarity, while a similar association argued that binding rules were necessary in some cases as a result of the difficulty in reaching an agreement with all of the industry stakeholders involved. An association representing road operators, as well as three public authorities, noted that, while legally binding rules should govern data protection, IT security and interoperability, soft controls may also support these. An association representing road surfacing interests supported the conclusions of the C-ITS Platform report that there was a need for an appropriate EU framework, noting in particular that there was a need to identify the roles of entities at the EU level that would be responsible for supporting the deployment of C-ITS and to define the necessary financing schemes.

On the other hand, an association representing vehicle manufacturers (along with two manufacturers) believed that an industry-led approach was sufficient for delivering most of the priorities and indeed that it was already doing so, although they noted that due consideration needed to be given to issues around the allocation of the radio frequency spectrum. An association representing the bicycle industry also noted that industry would be able to deliver services and interoperability, although the EU could support this by developing guidelines or specifications, and by addressing data and consumer protection. An association representing transport operators argued that an industry-led approach should be preferred where this was sufficient, although an EU framework for data privacy, data protection and security would be useful. They also noted that where the GDPR provides to be insufficient, soft legislation could be used to fill the gaps. The latter point was also made by an association representing public transport operators, with an additional point that fully anonymised data should always be preferred to pseudo-anonymised data. They also explicitly noted that the continuous availability of the system must at least be guided by recommendations at the EU level. A city network supported EU action on security, product safety and data, but argued that it should be left to road authorities to select the C-ITS services that were most appropriate for its needs, particularly as most Day 1 services had been designed for motorways and so were less relevant to cities.

An association representing road operating companies argued that if EU rules focusing on safety could be laid down, their implementation should be left to the market. Two associations representing consumers provided a similar response noting that a market-driven approach for the deployment of C-ITS was appropriate, with the Commission providing guidance or legislation to ensure data protection and the security of communication.

Associations representing telecommunications interests raised a number of issues. One noted that the mobile telecommunications industry was experienced in providing secure products and services to their customers, and that their industry has already delivered security guidelines and tools that covered connected cars, which it provided with its response (See Section E.4). They also noted that while privacy and trust were important for the consumer adoption of C-ITS, these should be addressed in the context of the GDPR, an issue on which they sought legal certainty and clarity. Another telecommunications association (and a private company) noted that EU action should focus on providing clarity on security and data protection and that it should build on existing and ongoing standardisation processes, while ensuring technology neutrality and stimulating innovation and ‘market-based technology choices’. It also noted that it provided evidence (Section E.4) of the benefits associated with co-existence of different technologies in the 5.9 GHz band of the radio frequency spectrum.

An association representing road operators recognised the importance of having a common system within the context of a general EU framework, but called for a legally binding approach to be avoided. They made reference to the Directive on electronic tolling in this respect arguing that a binding approach risked limiting the development of the market and the applicability of systems in all Member States.
Several respondents from associations reiterated their responses to previous questions about the need for additional EU legislative action. A repeated response from six associations representing distributors of replacement automotive parts and diagnostic tools (and one private company) argued that market forces would not allow the full benefits of C-ITS to be achieved. In order to enable this, an EU level legislative framework was needed ‘that covers the standardised vehicle technical specification/functions to provide access to the vehicle, its data and resources, together with the ability to safely and securely exchange data with the vehicle’. They argued that this should include vehicle type approval, as well as safety and security guidelines. An association representing cyclists called for C-ITS to be incorporated into EU Regulations on general vehicle safety.

Two associations representing insurers provided similar responses calling for EU rules to ensure in-vehicle access to vehicle data, either through an on-board application platform, or an in-vehicle interface, otherwise consumers would not have access to the full range of services and service providers. Two associations (and a private company) concerned with vehicle inspections called for the revision of Directive 2014/45/EU on the periodic inspection of vehicles to include ‘IT security’ and ‘data protection’, which should include a functionality test. They also argued that there was a need to clarify type-approval requirements in order to ensure that the mode of action and operation of ‘safety-related and environment-related systems and components’, as well as the integrity of the vehicle software, were documented in the course of vehicle type-approval. Finally, they urged policy makers to ensure that C-ITS was able to demonstrate that it can co-exist with the adjacent 5.8 GHz radio frequency spectrum band that facilitates electronic road user charging.

Most of the respondents from private companies who elaborated on their responses to Question 12 provided a reason why they supported EU action. Reasons provided by individual suppliers for binding EU action included that this would help: to ensure that costs remained at acceptable levels; to facilitate adoption; to provide legal certainty; to enable uninterrupted cross-border travel; to ensure that the benefits of safer roads were delivered; and because otherwise industry would not introduce road safety applications. A transport operator commented that EU action made sense to support new technical systems and replace outdated rules in Member States, while a company working in ITS noted that EU action was necessary in order to ensure that C-ITS served a public purpose. While supporting EU action, a supplier noted that EU action should take account of the maturity of the technologies concerned and the deployment of the necessary infrastructure, while another commented that EU action should focus on consumer protection and ensuring compliance with common rules that enhance competitiveness between companies. A telecommunications company was more supportive of soft EU action.

In their responses, some private companies highlighted the role for industry in the context of EU action. A supplier noted that the ITS Directive had not significantly increased deployment of ITS, so that more dedicated EU action was needed to ensure that C-ITS were deployed. However, they highlighted that EU action should still provide industry with the room to innovate, although this should not involve self-regulation. Another supplier made a similar point that EU action should not prohibit the deployment of C-ITS, while a research network underlined that it should be industry that developed C-ITS. An ITS service provider was favourable of EU action, but noted that this should be supported or even led by industry, while a similar company supported EU action on data protection and compliance assessment, but suggested that in other areas an industry-led approach was favourable to enable innovation.

A supplier preferred that industry be allowed to self-certify, while a vehicle manufacturer preferred ‘soft certification’ with respect to data protection. The manufacturer also believed that it was not necessary to re-open the discussion about the hybrid communication approach at this point in order to avoid potential issues with interoperability and backwards compatibility, although they noted that additional standards might be necessary to handle any future ‘multi-channel configuration’. Another supplier felt that EU action was necessary in order to overcome the commercial interests of the more powerful players, but noted that soft EU regulation would be more preferable as strict regulation might hinder innovation.

A telecommunications provider was less convinced that EU action on C-ITS was necessary, noting that in the Nordic countries cellular communication was the superior option. They argued that EU action could help to support the development of cellular coverage across the EU, with a focus on roads. A consultancy argued that governments in general should not introduce legislation that seeks to direct technology or service solutions.
A car rental company and a company involved in the repair and replacing of vehicle parts reiterated their response to earlier questions by calling for EU action to develop a binding legal framework to ensure fair and interoperable access to in-vehicle data for all market operators in order to protect consumer rights and to promote innovation.

Various reasons, and caveats, were provided by public authorities that supported EU action. Public authorities that supported EU action across the board argued that: without binding EU action unified deployment would not be possible; otherwise implementation would be slow; and in order to ensure that C-ITS were deployed. Two public authorities provided a caveat to their support of EU action to underline that the relevant industries should be involved in the process. Two public authorities were more selective, with one highlighting that EU action was essential for data protection, IT security and interoperability, with the other highlighting the need for EU action on compliance assessment, principles for the C-ITS data value chain, communications standards and the selection of a small number of priority services and actions.

A number of public authorities focused on the boundaries between binding legislation and softer action. One noted that whatever was needed to ensure that the technology that was procured was interoperable should be subject to binding legislation, whereas a softer approach for the generation of C-ITS services would be more appropriate. A similar response highlighted that binding action was important where security, privacy, data protection and conformity were important, but that industry should play a leading role in the provision of services. A national ministry noted that EU regulation should be preferred to ensure interoperability and to protect rights, whereas industry should be referred to in relation to the provision of technical standards. A national roads office noted that legal binding legislation should not be too detailed.

A number of national ministries were more cautious. One noted that the softest possible solution was currently the best, and that it was not yet clear where there was a need for further regulation. Another national ministry noted the importance of standardisation at the EU level, but preferred these to be of a ‘non-binding and advisory character’. A third argued that for policy areas such as C-ITS, where industry had a very important role, a consensual approach forward was more appropriate, supported by memoranda of agreement.

A provincial authority was less convinced of the need for EU action, suggesting that Europe should instead be the platform where discussions are held and agreements are reached. A national transport administration noted that, from their perspective, their main concern was with the issues that were of their concern, e.g. roadworks and emergency vehicles, whereas other C-ITS should be left to manufacturers.

The NGO respondents who elaborated their response to the previous question generally provided reasons for their support of EU action. These included: to ensure interoperability; to protect users; and to avoid the abuse of loopholes in softer action. One NGO respondent noted that the binding rules should not be restrictive, while another noted that it was industry’s role to develop new services. An NGO focused on the protection of consumer rights additionally called on EU action to set a detailed timetable for the introduction of safety-related C-ITS services and a clear set of targets for implementation. They also proposed the creation of a new platform that brought together all relevant public and private stakeholders in order to facilitate the swift updating of the relevant legislation. One NGO representing cyclists commented that the question was badly worded, as Member States were also able to regulate and that not all C-ITS required regulation. Reiterating a response to a previous question, they noted that Intelligent Speed Assistance (ISA) should be included within EU type approval.

Responses from citizens varied. One noted that binding rules were important to ensure that action was taken, while another stated that binding EU action, at least in the early stages of deployment, was necessary to avoid fragmentation and a decline in safety and functionality. On the other hand, another citizen preferred a softer approach, as they considered that it was difficult to legislate in areas involving innovative technologies. One citizen noted that implementation was dependent on the communication technologies that were used, and this was where industry was in the driving seat. The importance of the market and the behavioural response of users was raised by one citizen, who noted that it was appropriate for industry to lead in most of the proposed areas.

As with citizens, responses from those who categorised themselves as ‘Other’ varied. One noted that EU intervention was needed in relation to the security of C-ITS communications, but the remaining objectives should be achieved through a harmonious combination of EU and industry action. Another
response supported regulation to ensure the continuous availability, interoperability and seamless deployment of C-ITS services, but preferred that the hybrid communications approach be negotiated with industry. With respect to security and data protection, they noted that generic EU legislation was already in place, while it was proving difficult to introduce binding legislation for technology that was relevant to C-ITS, which was still developing. Consequently, they were concerned that binding legislation in these areas would prove to be a barrier for development and deployment. Other responses underlined that a clear definition of services was necessary, and that the approach to delivering a hybrid communications approach should be technology-neutral and based on a memorandum of understanding with industry, which could be a prerequisite for the allocation of the appropriate bands of the radio frequency spectrum.

**E.3.2.11 Q14. Please indicate if you agree with the following statements on accelerating deployment of C-ITS (when services are fully functional and EU-wide specifications are in place) (n=131-132)**

Table E-13 below presents the statements being considered in terms of accelerating deployment of C-ITS.

<table>
<thead>
<tr>
<th>Statement No</th>
<th>Statements considered for accelerating deployment of C-ITS:</th>
<th>Shortened name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>14a</td>
<td>Enabling conditions such as exchange of best practice and funding instruments are sufficient, thus there should be no mandatory deployment of C-ITS.</td>
<td>‘No mandatory deployment’</td>
</tr>
<tr>
<td>14b</td>
<td>C-ITS equipment should be mandated in new vehicles</td>
<td>‘Mandated in new vehicles’</td>
</tr>
<tr>
<td>14c</td>
<td>Retrofitting C-ITS equipment in existing vehicles should receive financial support</td>
<td>‘Retrofitting financial support’</td>
</tr>
<tr>
<td>14d</td>
<td>C-ITS roadside equipment should be mandated on core interurban transport routes (i.e. those in the core trans-European network (TEN-T))</td>
<td>‘Mandated on core routes’</td>
</tr>
<tr>
<td>14e</td>
<td>C-ITS roadside equipment should be mandated on all main interurban transport routes (i.e. those in the comprehensive trans-European network (TEN-T))</td>
<td>‘Mandated on main routes’</td>
</tr>
<tr>
<td>14f</td>
<td>C-ITS roadside equipment should be mandated on all main interurban transport routes AND urban nodes (i.e. those in the comprehensive trans-European network (TEN-T))</td>
<td>‘Mandated on main + nodes’</td>
</tr>
</tbody>
</table>

Figure E-27 shows that response on the agreement of each statement in terms of accelerating deployment of C-ITS was slightly mixed. A moderate proportion of respondents (60-84 out of 131-132 (45-64%)) indicated they strongly agreed or agreed with all statements, apart from ‘no mandatory deployment’ (14a) where only 40 out of 132 (30%) did. The most supported statement was C-ITS equipment to be ‘mandated in new vehicles’ (14b). For ‘no mandatory deployment’, a large number of respondents (68 out of 132; 51%) disagreed or strongly disagreed. In comparison, the number of respondents for all other statements was between 25 and 39 (19-30%). The number of the respondents who both neither agreed nor disagreed or had no opinion/did not know was small (19-28 (14-21%) and three-10 (2-8%) respectively).
When responses were analysed by stakeholder group, consensus between the stakeholders was identified in most areas. There was an approximately identical split within each stakeholder group when looking at objectives: ‘retrofitting financial support’ (14c), ‘mandated on core routes’ (14d), ‘mandated on main routes’ (14e) and ‘mandated on main + nodes’ (14f). For example, for all stakeholders that responded to the objective ‘mandated on main routes’ (14e), between 46-54% agreed or strongly agreed with the statement (except Other – 20%). Within these four objectives, public authorities tended to have the largest proportion of respondents disagreeing/strongly disagreeing (between seven and 13 out of 31). For the least favoured ‘no mandatory deployment’ statement (14a), it was association respondents that had the largest number of respondents disagreeing/strongly disagreeing (20 out of 35; 57%) (see Figure E-28). No citizen respondents across all statements had no opinion/did not know compared to between one to four out of 35 associations.
Figure E-28: Response on the level of agreement of statement ‘Enabling conditions such as exchange of best practice and funding instruments are sufficient, thus there should be no mandatory deployment of C-ITS’ (14a), by stakeholder group

When analysing by representing interest¹, consensus was seen for some objectives over others. For ‘no mandatory deployment’ (14a), ‘mandated in new vehicles’ (14b), and ‘retrofitting financial support’ (14c) there was a fairly even distribution between each of the representing interest groups. For example, for the most favoured objective of mandating in new vehicles (14b), at least 50% of respondents from all interest groups stated they strongly agreed or agreed with this (except ITS service providers (29%) and the single road user response) (see Figure E-29). In comparison, for objectives ‘mandated on core routes’ (14d), ‘mandated on main roads’ (14e) and ‘mandated on main + nodes’ (14f), responses varied widely across the different interest groups. For example, when looking at the objective of mandating on core routes (14d), 73% of respondents representing interests in vehicle and equipment manufacturing/suppliers/repairs strongly agreed or agreed, compared to just 13% of road/transport operators.
E.3.2.12 Q15. Please elaborate on your answers to the previous question (n=98)

Ninety eight respondents elaborated on their answers to Question 14, of which 28 came from associations and 27 were from companies. The remaining responses included 24 from public authorities, eight from NGOs, five from citizens and six from respondents who classified themselves as ‘other’.

Several respondents from associations that supported some form of mandate explained their responses. Two associations representing insurers highlighted the need for mandatory action to deploy C-ITS infrastructure on the most important inter-urban routes as these were of most importance to the
transport of people and goods in Europe, while an association representing automotive importers noted that mandates were important wherever there was significant traffic. An association representing road surfacing interests supported mandates on core corridors as they believed that this was an opportunity to develop C-ITS solutions. A repeated response from six associations representing distributors of replacement automotive parts and diagnostic tools (and one private company) supported mandates, noting that every non-connected vehicle risked adversely affecting the efficiency of the whole network. An association representing the bicycle industry noted that mandating C-ITS was a good way of improving the level of service experienced by road users, while another representing traders of automotive parts noted that mandates were a good means of ensuring the quick deployment of C-ITS. A consumer organisation supported mandates on interurban routes and the consideration of vehicle retrofit, arguing that the benefits to the consumer must be the first consideration.

Two associations (and a company) involved in vehicle inspection noted that it was important for the Commission to establish a clear timetable for the implementation of C-ITS, with a focus on ensuring that C-ITS services that improve safety were mandatory. They noted that retrofitting older vehicles should be considered if it proved to be cost-effective. An association representing telecommunications interests noted that a mandate would help speed up effective deployment, but called for a distinction to be made between ‘roadside equipment’ and ‘C-ITS equipment’ in order to better distinguish the responsibilities of different industries.

An association representing vehicle manufacturers (as well as two manufacturers) supported infrastructure mandates as they would accelerate the acceptance and use of C-ITS applications that were being provided in vehicles. An association representing road operators (along with three cities) supported mandates for vehicles and on urban nodes, as long as the latter was accompanied by the necessary funds. A network of ITS interests supported mandates, but was not convinced that retrofitting vehicles was technically feasible. An association representing logistics interests supported mandates on vehicles and inter-urban routes, but not yet the other proposals, as a step-wise approach was best.

Rather than agreeing or disagreeing with most options, an association representing transport operators made a general point that urban areas should be more involved in the development of the policy framework for C-ITS, whilst ensuring that local freedom of action was maintained.

On the other hand, a city network stated that generally mandating the deployment of technology should be avoided, as the reason to mandate C-ITS over many ITS, for example, was not clear. They underlined that mandates for roadside infrastructure were only workable if accompanied by the necessary finances. An association representing public transport operators noted that mandating retrofitting should only be considered where it was technically feasible at a low cost, or was heavily subsidised, while mandating roadside equipment should only be considered if it were prioritised on the number of people transported. Two associations representing road users provided a similar response that they favoured a market-based approach for the development of C-ITS, supported, if at all, with funding. An association representing transport companies made a similar point that if there was no obvious need for cities to introduce C-ITS and no justification for a mandate.

An association representing infrastructure operators noted that road operators will implement C-ITS where it is beneficial, while mandating a particular communications technology that may be superseded did not make sense. An association representing telecommunications interests implied that a mandatory approach would be neither technology-neutral nor promote effective competition. Another telecommunications association (and a private company) referred to a study that concluded that the most benefit from C-ITS deployment came from scenarios where there was no mandate requiring the implementation of roadside units set up to use the 5.9 GHz radio frequency spectrum band.

As with responses from associations, many respondents from private companies elaborated on their reasons for supporting some kind of mandate, while a few explained why they were not supportive of any type of mandate. Two suppliers supported all of the options presented in Question 14 with one noting that a minimum set of C-ITS services should be mandated to ensure that a minimum set of C-ITS were deployed, while the other noted that it was important to consider the maturity of a technology before mandating its deployment. An ITS equipment and service provider noted that a mandate should not be geographically restricted. Three suppliers supported all of the proposed mandates, but did not support retrofitting even though two of these noted that retrofitting might be important in the longer-term. One justified this on the basis of providing a clear political signal, while another supported mandates only in situations where there were clear road safety benefits. One supplier and an ITS
service provider supported mandating C-ITS in vehicles and on inter-urban infrastructure in order to ensure that C-ITS was implemented and that it delivered wider societal benefits.

Another ITS service provider supported mandatory action on infrastructure, as mobility was a cross-border activity; a supplier reached a similar conclusion as greater advances were currently being made in deploying C-ITS on vehicles than in infrastructure. Two vehicle manufacturers also supported mandates for infrastructure, but not vehicles, as the latter were already being implemented and that a good road network coverage was important for enabling many Day 1 services.

Two telecommunications providers only supported mandates for the deployment of C-ITS in vehicles and for financial support to be given for retrofitting old vehicles, as did a supplier and another company working in the repair and replacement of vehicle parts. One of the former noted that it was in vehicles where the challenge currently was, while the other argued that this was important to gain consumers’ trust. The repair company commented that only such an approach would ensure consistency across the market and bring C-ITS to consumers. A similar argument was made by the supplier, i.e. that the consistent use of C-ITS technology was needed by as many stakeholders as possible in order to attain a critical mass in the Member States. A supplier supported retrofitting connected cars with safety-enhancing cheap features, such as the ‘sharing of anonymised friction information’.

Five private companies elaborated on why they were not in favour of any mandated deployment of C-ITS. A transport operator argued that the focus of C-ITS should be on improving public transport by means of assistance for drivers in order to improve the attractiveness of public transport. A telecommunications provider argued that mandating a network of roadside infrastructure based on old technology would be costly, proposing instead that the focus should be on gaining maximum advantage from the use of cellular networks. An ITS service provider also questioned whether C-ITS based on roadside equipment was the best way forward given advances in other technologies. A consulting company was not convinced that there was clear evidence of the benefits from the large scale deployment of C-ITS and so concluded that it was inappropriate to mandate C-ITS at this stage. Another consultancy argued that transport agencies in many countries were trying to remove sensors from their roads, as these were difficult to install and costly to maintain, so additional (C-ITS) infrastructure should not be mandated on roads.

Of the public authority respondents, two regional governments and one national ministry elaborated on their support for all the options proposed in Question 14. One of the former noted that this should be undertaken at the latest when road maintenance was planned, while the other argued that without mandating C-ITS in vehicles the investment in infrastructure being made by cities would not be justifiable. The national ministry commented that without a mandate, it would be difficult to achieve the necessary economies of scale. A regional authority and a national ministry supported most of the Options proposed in Question 14, other than a mandate involving urban nodes. The former argued that a mandate would ensure that C-ITS was deployed and that it would make the responsibilities clear, although they believed it would be difficult to mandate deployment near cities. The national ministry called for the installation of roadside equipment as long as this was justified on the basis of a cost-benefit analysis. Two city authorities (and a citizen) also supported mandates, other than for cities, arguing that C-ITS had to be proven in the relatively simple case of inter-urban routes before being used in the more complex environment of cities.

Two authorities supporting all of the options proposed by Question 14, other than retrofitting. Both felt that these were important to ensure that C-ITS was implemented in a reasonable timeframe, with one noting that it would help to overcome the ‘chicken-or-the-egg’ problem. Additionally the latter suggested that, if vehicles were retrofitted with C-ITS, it would make the vehicle non-compliant with type approval legislation. A national roads administration supported mandates for C-ITS in vehicles and on the main interurban routes, but was not in favour of retrofitting as this risked leading to unexpected malfunctions.

A city and a regional authority only supported mandates for infrastructure, with one arguing that spending more money on cars may not be desirable if a city wants to focus more on bicycles, pedestrians and public transport. The other noted that there was a need for cooperation between government and the market with respect to the deployment of C-ITS, with the former needing to invest heavily in roadside infrastructure.

One national and two regional authorities supported mandates for vehicles and support for retrofitting, but not mandates for infrastructure. The former noted that installing roadside infrastructure everywhere would be costly and that public authorities were ahead of vehicle manufacturers in terms of deployment,
so that it was more appropriate to mandate C-ITS deployment in vehicles. One of the regional authorities was also concerned about the cost of mandating roadside equipment, while the other noted that C-ITS that promotes road safety should be mandated. Two national road administrations only supported mandating C-ITS in vehicles. One noted that they were already equipping their roads with the necessary C-ITS infrastructure, while the other noted that implementation should be allowed to respond to regional needs, and so there should be a general requirement to have sufficient communication coverage for C-ITS applications rather than a mandate.

A national roads authority did not support mandates, questioning whether this was a viable path to the widespread deployment of C-ITS. A national ministry was also not in favour of any sort of mandate as it considered that there was already a sufficient amount of incentives in support of the development of connected vehicles. Furthermore, they suggested that if the use of cellular technology was extended, the coverage of C-ITS on the road network could be increased in a much more efficient manner. Another ministry chose not to answer Question 14, as the direction of technological development was not yet clear, nor were the wider impacts of C-ITS deployment.

Three of the NGO respondents elaborated on their reasons for supporting all of the options listed in Question 14, which included that otherwise deployment would take longer and thus the subsequent benefits would be delayed. Another NGO supported all mandates, but not retrofitting, as it considered that this would be too costly. Instead, it suggested that ‘retrofitting’ might be achieved through services on a smart phone. With respect to infrastructure, they considered that the use of cellular systems would not entail much in terms of additional cost, although gaps in coverage, e.g.in tunnels, would need to be addressed. An NGO representing cyclists noted that some C-ITS should be mandatory in vehicles, such as Intelligent Speed Assistance, while support should be given for retrofitting where this would bring safety benefits. An NGO representing road users did not support any type of mandate arguing that making C-ITS mandatory in new vehicles would infringe on the rights of individuals, while mandating C-ITS on infrastructure would breach the principle of subsidiarity.

Two citizens that elaborated on their responses to Question 14 supported most of the options of Question 14, one was supportive of only selected options, while two were not in favour of any mandate. The former underlined that they were supportive as long as the security of the system was assured. The citizen that only supported a mandate on interurban routes argued that it was easier to impose something on a limited length of road in the first instance, which could then act as a spur to action on other roads. One of the citizens who opposed any form of mandate argued that mandating deployment of roadside C-ITS infrastructure may not be the most economical solution, while retrofitting risked low quality solutions that could put the future development of C-ITS at risk. Additionally, they pointed out, as did the other citizen who opposed mandates, that collaboration with the telecommunications industry might be a better and cheaper way of ensuring a wide coverage of C-ITS on the road network.

Of those respondents that categorised themselves as ‘Other’, two supported a mandate for C-ITS in vehicles and the retrofitting of existing vehicles. One of these argued that deployment of C-ITS roadside infrastructure would follow if vehicles were equipped with C-ITS, while the other noted that roadside equipment should only be installed if there was a need to improve road safety or to manage traffic better. Another, which only supported retrofitting, argued that there was a need to involve urban areas more in the discussions on C-ITS, including public transport operators. At the same time, they noted that it was important to respect subsidiarity and ensure local freedom of action in the implementation of C-ITS, which should be supported financially as it would benefit all road users. Another respondent, which also supported retrofitting, noted that C-ITS should be used to prioritise public transport and promote modal shift. Another respondent, while not in favour of any mandate, noted that regulating C-ITS on vehicles and on infrastructure might be beneficial, but that the latter in particular would not be easily achievable. If infrastructure were to be regulated, they preferred a requirement that a specific part of the network be covered by C-ITS communications, rather than mandating roadside equipment.

### E.3.2.13 Q16. From your point of view, are there actions missing that should be considered at the EU level? (n=85)

Eighty five respondents answered the question about missing actions that might be considered at the EU level. Twenty eight of these came from associations, while 23 came from private companies. Sixteen public authorities also provided a response, as did seven NGOs, six citizens and five from those who categorised themselves as ‘other’.

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The most common theme raised by *associations* was to do with access to, and the handling of, data. In many cases, these reiterated comments made in response to earlier questions. A repeated response from seven associations representing distributors of replacement automotive parts and diagnostic tools (and one private company) argued for a regulatory framework to ‘implement a standardised solution that considers the widest benefits of exchanging in-vehicle data (beyond just C-ITS)’ in order to enable innovation and the development of competing services. Additionally, the same set of associations noted there needed to be a process to ensure that software in both infrastructure and vehicles was updated regularly.

Two associations representing insurers also provided a similar response that EU action on in-vehicle access to vehicle data was needed. Similarly, three similar responses from two associations and one company involved in motor vehicle inspection noted that an agreement needed to be reached on access to data, while also noting that recommendations should be made for the appropriate design of the human-machine interface for C-ITS. A consumers’ organisation underlined the need for regulation to address the handling of non-personal data.

A number of associations raised the need for additional financial actions. An association representing vehicle manufacturers (along with three manufacturers) proposed that incentives be provided for fitting C-ITS to new vehicles, and potentially for retro-fitting older vehicles. An association representing infrastructure operators called for financial support for the implementation of the various types of infrastructure needed for C-ITS, while an association representing suppliers called for action to ensure that public-private investments were made available to support the first phase of C-ITS deployment.

A couple of associations highlighted the need for more information. An association representing transport operators (as well as similar responses from three city authorities) called for support for authorities in the form of a comprehensive range of information, including training, as well as more opportunities for municipalities to participate in the development of standards and of the implementation process. A logistics association called for information campaigns and awareness raising.

An association representing telecommunications interests underlined the need to recognise the role of telecommunications infrastructure as a part of C-ITS, which would include the provision of a regulatory means to enable network resources to be shared to speed up deployment and ensure that competitive integrated solutions could be offered. Other suggestions for action to support the deployment of C-ITS included some sort of forum in which problems could be analysed and countermeasures identified (from a network of those with an interest in ITS) and action to contribute to the global harmonisation of C-ITS services and systems (from an association representing digital interests). An association representing telecommunications interests (and a similar response from a company) noted that whatever policy framework was proposed, it should be sufficiently flexible to allow technologies and solutions to adapt to developments in technologies.

A number of associations made more general comments in relation to actions that were missing. Two representing public transport operators provided similar responses that noted that one aspect that was missing from the consultation was the possibility of using C-ITS to grant priority to public transport, and to collective and shared transport, more generally. They argued that if one of the aims of C-ITS was to improve the efficiency of road use, it should be centred on public, not private, transport. Two similar responses from consumer organisations proposed setting up a test market (rather than operational tests) to identify the impacts of C-ITS in the real-world before it was implemented more widely. A city network proposed that rather than legislate to accelerate deployment, more funding for C-ITS should be provided through programmes, such as Horizon 2020 and CIVITAS. An association representing cyclists called for more action to deliver safety benefits, including the introduction of virtual number plates for cars, as well as future-proofing C-ITS modules that are fitted to cars.

Several respondents from *private companies* mentioned additional EU actions that might be considered. A supplier suggested that road weather information would be important in determining road weather conditions for highly automated driving, so this needed EU-wide standardisation, including a minimum network density and ensuring that the public can access the relevant data in real-time. A company involved in repair and replacement of vehicle parts underlined the need for an EU regulatory framework to govern access to in-vehicle data for the aftermarket.

An ITS service provider called for more awareness actions targeting end users, while a supplier called for more intensive and structured discussions at the EU level to avoid the risk of Europe falling behind other parts of the world. A research network proposed that a forum be set up in which the different views...
could be aligned and the different interests balanced in order to synchronise the further development of C-ITS. A consultancy called for the evidence of the ongoing trials, and the analysis of the outcomes, to be brought together.

A number of companies raised the issues of technology. While a supplier called for a conclusion to the debate about the use of the 5.9 GHz radio frequency spectrum band, as this was deterring investment, other companies proposed shifting the focus on other technologies. An ITS service provider proposed that the current approach be ‘pivoted’ towards a data-driven approach using data from *inter alia* vehicle sensors and smartphones, while a similar company called for a cloud-based platform to complement road-side and in-vehicle equipment. A telecommunications provider called for a focus on a cloud- and smartphone-based solution making use of existing data. A consultancy argued that the focus of EU action should be on ensuring that communications-based systems and services can be operated safely and legally, rather than on defining these services and systems.

Additional actions mentioned by companies included: organise a C-ITS maturity model for Member States with a mandatory minimum level of implementation (from a telecommunications provider); and to ‘freeze’ the ITS standard, at least for the transmission layers (a supplier). Another supplier underlined that C-ITS are not the sole measure to improve road safety and mobility, and so should be balanced by measures to deliver clean mobility and further behavioural change in the transport sector.

From the perspective of **public authorities**, one municipality called for more coordination between different authorities, more finance to support tests, more communication to the public and public authorities, as well as more monitoring of technical developments and barriers to implementation. Similar themes were taken up by other respondents. Two city authorities (repeated by a citizen) suggested that it would be beneficial to promote one-off measures to test and raise awareness of C-ITS on urban nodes, while other city authorities mentioned more money for urban infrastructure and the need for more comprehensive information to communities and cities.

A national authority called for the development of a clear strategy for the provision of C-ITS services and public responsibility in line with the EU’s Digital Agenda. They argued that this was needed as there were many views in the EU as to where responsibility lay for different elements of C-ITS. A regional authority called for liability issues to be resolved.

A national ministry called for an evaluation of the readiness of different Member States to deploy C-ITS, as it noted that implementing C-ITS was not one of its top priorities. A regional authority noted that there should be more action on C-ITS for public transport with the aim of limiting private car use. A national ministry proposed that, after the adoption of the anticipated Delegated Act on C-ITS, the Commission produced a proposal to make the application of C-ITS mandatory in the way that has been done with eCall under the ITS Directive.

Some of the **NGO** respondents raised wider issues in response to the question about the EU action that was missing. While one called for an agreement on the priority services, another called for more active Commission involvement in information campaigns targeting the general public in order to address the many myths that surround ITS more generally. An NGO representing cyclists called for the inclusion of cycling and walking in the process of harmonising and standardising ITS and C-ITS in order that these modes were not left behind and instead seen as part of smarter transport technologies and services. It was noted that both electric-assisted bicycles and public bike share systems are becoming more advanced and will become more important as ‘mobility as a service’ develops. Another NGO representing road users noted that the EU’s legal framework needed to consider the interaction of connected and non-connected vehicles. Another NGO underlined that any future transport system involving C-ITS should take account of the needs of those with disabilities and should not discriminate against these groups.

**Citizens** raised some similar additional actions to those already mentioned by other stakeholders. These included that: access to data needed to be agreed upon; that there needed to be adequate publicity given to the various ongoing actions; and that a commission of independent experts should be set up to identify any faults in C-ITS equipment before it is put on the market. A citizen called for the centralisation of the decision making process in order to avoid long discussions between all national representatives. Another noted that the radio spectrum frequency band used by light rail had not been mentioned and wondered whether trams would be integrated into C-ITS.

One response from those who categorised themselves as ‘**Other**’ was that awareness raising and training targeting end users was important, while another commented that the EU should take more

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action to promote 'mobility as a service' projects that were closely related to C-ITS technology. Another noted that there was a need for research and practice on the business side, not just on the technology side. This needed to focus on the real problems of end users and on designing business models to address these needs. A respondent also called for the work on digital information to be intensified and extended, as harmonised traffic rules will be needed to implement Day 2 services.

**E.3.3 Impacts**

The next seven questions of the PC looks at the impacts of C-ITS. Within this, the Commission has made a preliminary assessment of the most relevant impacts of substantial deployment of C-ITS (assuming that C-ITS equipment will be progressively deployed up to 2030 to eventually cover all new vehicles types/segments, all highways of the TEN-T core network and select other roads and urban nodes) which are presented in Question 17.

**E.3.3.1 Q17: Please indicate your level of agreement with the following statements (n=134-136)**

Table E-14 below presents the most relevant impacts of substantial deployment of C-ITS.

### Table E-14: Impacts considered for Question 17

<table>
<thead>
<tr>
<th>Statement No</th>
<th>Potential impacts of substantial deployment of C-ITS:</th>
<th>Shortened name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>17a</td>
<td>Investment costs for in-vehicle C-ITS equipment will be very substantial (i.e. the major part of overall costs)</td>
<td>'In-vehicle investment costs’</td>
</tr>
<tr>
<td>17b</td>
<td>Investment costs for roadside C-ITS equipment will be substantial (but a minor part of overall costs)</td>
<td>'Roadside investment costs’</td>
</tr>
<tr>
<td>17c</td>
<td>Investment costs for central C-ITS equipment (e.g. integration to national traffic management centres, software development) will form a small part of overall costs.</td>
<td>'Small central investment costs’</td>
</tr>
<tr>
<td>17d</td>
<td>The deployment of C-ITS will make a strong contribution to improving road safety</td>
<td>'Improved road safety’</td>
</tr>
<tr>
<td>17e</td>
<td>The deployment of C-ITS will make a strong contribution to reducing congestion</td>
<td>'Reduced congestion’</td>
</tr>
<tr>
<td>17f</td>
<td>The deployment of C-ITS will make a significant contribution to more efficient use of road infrastructure</td>
<td>'Efficient road infrastructure use’</td>
</tr>
<tr>
<td>17g</td>
<td>The deployment of C-ITS will deliver a small reduction in the expenditure needed for road infrastructure (both expansion and maintenance)</td>
<td>'Decreased infrastructure spend’</td>
</tr>
<tr>
<td>17h</td>
<td>The deployment of C-ITS will make a small contribution to reducing pollutant and CO2 emissions</td>
<td>'Reduced pollutant and CO2 emissions’</td>
</tr>
<tr>
<td>17i</td>
<td>The deployment of C-ITS will have a positive impact on international competitiveness of EU companies</td>
<td>'International competitiveness’</td>
</tr>
<tr>
<td>17j</td>
<td>The deployment of C-ITS will have a positive impact on research and innovation</td>
<td>'Research and innovation’</td>
</tr>
<tr>
<td>17k</td>
<td>The deployment of C-ITS will support bringing new services and products to the market and thus creating new jobs</td>
<td>'New services/jobs’</td>
</tr>
</tbody>
</table>

Figure E-30 shows that response on the agreement of each impact from substantial deployment of C-ITS was mixed. For statements ‘improved road safety’ (17d), ‘efficient road infrastructure use’ (17f), ‘research and innovation’ (17j) and ‘new services/jobs’ (17k), a large number of respondents (105-113 out of 135-136 (77-84%)) stated they agreed. In comparison, for ‘in-vehicle investment costs’ (17a) and ‘decreased infrastructure spend’ (17g) only 37 and 44 out of 135 and 134 (27 and 33% respectively) agreed. ‘Decreased infrastructure spend’ was in fact split equally between agree, disagree and no opinion/did not know. ‘In-vehicle investment costs’ received the largest number of respondents who
disagreed (65 out of 135; 48%), compared to ‘research and innovation’ (17j) and ‘new services/jobs’ (17k) with minimal responses (4%). The number of no opinion responses was fairly evenly distributed across all statements (besides 17g).

Figure E-30: Response on the level of agreement of impacts from substantial deployment of C-ITS

When responses were analysed by stakeholder group, consensus between the stakeholders was identified in most areas. There was an approximately identical split within each stakeholder group when looking at statements ‘improved road safety’ (17d), ‘reduced congestion’ (17e), ‘efficient road infrastructure use’ (17f), ‘international competitiveness’ (17i), ‘research and innovation’ (17j) and ‘new services/jobs’ (17k). For example, between 70-90% of respondents across all stakeholders agreed with the most favoured impact ‘improved road safety’ (see Figure E-31). Private companies, associations, public authorities and other stakeholders had the largest proportion of respondents disagreeing (for example, for ‘small central investment costs’ (17c) 31-50% of respondents from these stakeholders disagreed, compared to only 18% of citizen respondents). Citizen, NGO and other stakeholders were most likely to have no respondents disagreeing.
E.3.3.2 Q18. Please elaborate on your answers to the previous question (n=88)

Eighty eight respondents elaborated on their answer to Question 17, of which there were 28 each from associations and private companies. A further 20 responses came from representatives of public authorities, five from NGOs, three from citizens and four from those who classified themselves as ‘other’.

Responses from associations that elaborated on their answers to Question 17 ranged from those that simply explained the reason for their response to those that were more critical or sceptical. An association representing the bicycle industry (and a similar response from a company) expected C-ITS to strongly improve travel efficiency and safety, with subsequent benefits for emissions. They also expected benefits in terms of increased transparency in terms of modal choice and pricing, which would enable bicycles, including e-bikes, to become part of an interconnected transport network. An association of automotive traders commented that similar vehicles in a standardised environment would improve traffic flow.

Some respondents commented on the type of impacts mentioned in the parts of Question 17. A vehicle manufacturers’ association (and similar responses from two manufacturers) believed that the impacts of C-ITS on reducing CO₂ and air pollutants would be substantial, not small, as had been indicated by an ERTICO study on the decarbonisation benefits of C-ITS. They also believed that there would be substantial benefits for safety. A network of ITS interests also believed that C-ITS would have a large impact on pollution and infrastructure expenditure.

A city network did not expect C-ITS to improve road safety and traffic efficiency in urban areas, with the exception of lorries and fleets, but noted that it had the potential to play a supporting role in traffic management. A logistics association was not convinced that C-ITS would have a real impact on congestion, as there would also need to be a reduction in the number of vehicles, for example, to achieve this. They were also concerned that the investment costs of roadside equipment might be higher than expected if this was undertaken in an uncoordinated manner. A network of ITS interests noted that, in order to take full advantage of C-ITS, traffic management centres and data clouds would be needed, while the cost associated with in-vehicle equipment will be high simply as a result of the number of vehicles involved. They also noted that while accidents should decline, any advantages in terms of capacity and emissions may be negated by increased traffic volumes.

An association of transport operators (and similar responses from three cities) expected a positive contribution from C-ITS to road safety, but thought that the impacts on efficiency were likely to be low in the beginning. However, they noted the positive benefit for the economy, as a result of the introduction of modern infrastructure. They also noted that it was important to challenge the belief that there would be low costs for the central equipment needed for C-ITS, as these would need a lot of adaptation.
The implications on various costs were the primary concern of a number associations. Two associations representing transport operators provided similar responses. They noted that while the costs per bus would be small, the investment costs for roadside equipment for the entire bus fleet would be substantial, which raised the question of who would pay for this. They also noted that C-ITS would only contribute to reduced congestion if combined with other measures, including a real urban and land use planning strategy, to ensure that there were not more private cars on the road. In this respect, they argued that C-ITS should be used as a catalyst to encourage shared mobility. An association representing road operators said that, while C-ITS would bring benefits in terms of safety and the optimisation of infrastructure, it was ‘illusory’ to believe that the investment costs for the implementation of C-ITS would be low. Two similar responses from consumer associations believed that costs for vehicles (as a result of the numbers involved), roadside infrastructure and the central management of C-ITS would be significant, while they were not convinced of the benefits for road traffic safety.

An association representing telecommunications providers noted that it had chosen to disagree with all of the statements in Question 17, as they often contained many premises, not all of which they agreed with.

Two associations (and a company) representing those involved with vehicle testing noted the wider environmental benefits of C-ITS, including noise. A consumers’ organisation noted that the impacts on road safety and emissions would only occur if the deployment of C-ITS was widespread and if older vehicles were retrofitted. An association of telecommunications providers noted that the impacts would be affected by the significant lead time to the widespread adoption of C-ITS, as a result of the time needed to renew the vehicle fleet, and only if users accepted the technology. An association representing those that trade in automotive parts underlined the need for a legal framework to standardise C-ITS if the impacts were to be realised. An association representing telecommunications providers (and a similar response from a company) noted the significant potential for job creation of C-ITS, but noted that achieving this was dependent on the technology used referring to a study carried out for 5GAA on this topic.

Two associations representing insurers provided a similar response re-iterating their points made in response to previous questions that the full benefits of C-ITS would only be achieved if there was a legislative framework at the EU level "to promote fair and equal in-vehicle access to vehicle data for all service providers". A repeated response from six associations representing distributors of replacement automotive parts and diagnostic tools (and one private company) underlined the need for an interoperable telematics platform that supported C-ITS in order to ensure that competing services could be developed. An association representing cyclists noted that making sure that C-ITS hardware was able to be used for many different C-ITS services would increase their use.

Responses from private companies ranged from those that explained their answers to those that believed that achieving the impacts were conditional on other actions. In addition to reducing emissions, an ITS service provider saw C-ITS as an enabler for higher levels of automation, while a supplier saw digitalisation as an essential element of a low emission transport system with new mobility services. A vehicle manufacturer noted that communicated information would contribute to Advance Driver-Assistance Systems, which would have CO2 benefits. Another manufacturer made a similar point, also noting that the CO2 benefits would be maintained as a result of traffic optimisation. One supplier underlined the potential safety benefits of C-ITS, while another suggested that the benefits in terms of efficiency and environmental impacts might be larger than implied by the respective statements.

As with associations, the main concern of a number of private company respondents were the costs. Three suppliers noted that the costs of the installation of roadside units would be much higher than those associated with the car. One subsequently argued that the former should be prioritised, while another noted that this could be offset by encouraging high value C-ITS applications, such as freight signal priority. An ITS research network noted that there were potential benefits from C-ITS, but noted that additional investment in traffic management centres would be important to realise these.

A number of companies made reference to cellular technology as a means of reducing the costs of infrastructure. A vehicle manufacturer noted that using cellular technology, as has been implemented in vehicles for e-Call, would not require a major investment in either vehicles or infrastructure. A telecommunications provider noted that many of the proposed C-ITS services could be implemented using existing cellular technology, which would not require significant investment. A consultancy argued that cellular-based solutions would require limited investment in vehicles and in infrastructure (although they argued that there was no evidence of the benefits of C-ITS on safety and emissions). Another
consultancy, while suggesting that the statements in Question 17 were poorly thought through, also noted that the costs of infrastructure would be less using a cellular network. An ITS provider argued that a focus on equipment and physical aspects was too limiting; instead it should be more on the data and associated software.

A telecommunications provider was more cautious noting that it would take years to deliver even a 50% penetration of C-ITS, so the benefits of C-ITS would appear very slowly. A supplier noted that C-ITS would not necessarily lead to a reduced number of cars, but noted that there were other means of achieving this. A car rental company and a company involved in the repair and replacing of vehicle parts reiterated that it was important to ensure that all market operators were able to access the relevant in-vehicle data in a readable and interoperable format if the benefits of C-ITS were to be delivered.

Some respondents representing public authorities also provided reasons to support their conclusions, while others were more cautious. A national ministry noted that C-ITS would reduce the direct and indirect costs of transport and would enable the better use of infrastructure, although they noted that achieving economies of scale was important to reduce the costs of the equipment. Another national ministry called for European funds to support the implementation of C-ITS, while a regional authority noted that, in addition to CO₂ benefits, C-ITS would allow information to be used more efficiently and thus jobs could be created.

A city authority noted that C-ITS was a prerequisite for reliable automated and networked driving in the future, which would bring safety benefits, although they were not convinced that C-ITS would make a significant contribution to peak hour traffic, as it was space that was lacking in this case. A regional authority noted that the benefits for safety would only be felt over time, and suggested that in the transition phase there may be negative impacts, e.g. as a result of pilots. Another regional authority also noted that the economic benefits of C-ITS would only occur once there was a certain level of penetration. A national authority noted that it was not clear where the roadside equipment was needed, and that the extent of the eventual coverage would have impacts on the costs of both roadside infrastructure and the central C-ITS equipment.

A municipality noted that some jobs would be created, while others would disappear. In the long-term, they suggested that a beneficial impact would be greater social inclusion, as C-ITS would facilitate the use of collective and public transport. A national ministry noted that their responses to Question 17 were only a rough estimate. They noted that the costs of in-vehicle and roadside C-ITS equipment could be substantial in an absolute sense, rather than only relatively as implied by the question. They noted that while positive impacts have been suggested by pilots, these were on limited areas, so the overall impact was still too uncertain to undertake substantial investment and to justify legal obligations. Another national ministry noted that the impacts would depend on the implementation model, suggesting that if an approach was imposed at this stage, it may deliver little in the way of benefits at a significant cost.

A national roads office argued that the cost of installing C-ITS equipment in vehicles would be substantial as a result of the need for the constant updating of these systems, while large investments would be needed for backend infrastructure. They also noted that C-ITS would only reduce congestion and CO₂ emissions if they were accompanied by other measures to ensure that excessive levels of traffic were not subsequently generated. A similar response from two city authorities (and a citizen) made a similar point that more efficient traffic would contribute to increased individual motorised transport, which would negate the benefits of C-ITS.

A regional authority noted that C-ITS alone would not deliver the benefits, as other mobility measures would also have to be implemented. Another regional authority made a similar point, that while technology would contribute a little to reducing congestion, behavioural change was more important. A national ministry believed that investment in central C-ITS equipment would account for a large part of the costs of deploying C-ITS, while they were not convinced of the benefits in terms of reduced congestion and lower road infrastructure costs.

An NGO representing road users underlined that the effects of the deployment of C-ITS would depend on the reaction of the public. They noted that while enlarging road capacity initially eases congestion, congestion soon returns, and they were concerned that there would be a similar impact from C-ITS deployment. A consumer group noted that costs could be reduced if cellular technologies were used and that C-ITS would only make a strong contribution to road safety if the right services were deployed and mandated. They also noted that while the need to maintain C-ITS equipment would increase the
need for expenditure on road infrastructure, if its use was more efficient, less expansion of the network might be needed, which would reduce expenditure.

A response from a citizen underlined the need for the use of C-ITS to be monitored to ensure that it did not endanger other users. Another citizen noted that C-ITS would clearly bring benefits for road safety as 90% of accidents involved a human factor. With respect to costs, they noted that these were uncertain, but did underline that for C-ITS to function properly more investment was needed in traffic management centres. They also noted that the impact on congestion relied on the sufficient penetration of vehicles equipped with C-ITS.

One of the respondents who classified themselves as ‘Other’ noted that they assumed that there would be benefits from a significant level of deployment of C-ITS on safety and congestion, but did not have the evidence to support this. Another respondent believed that there would undoubtedly be benefits for traffic management and the efficient use of infrastructure from the deployment of C-ITS, as long as there were sufficient communication capabilities. They did not believe that the costs of maintaining infrastructure would decrease, as the introduction of C-ITS would increase the complexity of infrastructure. Similarly, they did not believe that C-ITS would reduce the costs of constructing new infrastructure, although they noted that better performing infrastructure might delay the need for new construction. They also noted that C-ITS would create new kinds of jobs, but also that jobs would be lost as a result of automation. Another respondent noted the importance of considering lifetime maintenance costs, in addition to investment costs.

E.3.3.3 Q19. From your point of view, are there any missing impacts that should be considered? (n=71)

Seventy one respondents commented on whether any impacts were missing from those listed in the online public consultation. Nineteen responses came from both associations and private companies, with a further 18 responses from public authorities. Of the remainder, five came from NGOs, four from citizens and six from those who classified themselves as ‘other’.

Suggestions from associations of impacts that might be missing included the impact on the safety of ‘road agents’ and the impact of radio-frequency emissions, which was mentioned by an association representing vehicle manufacturers (and two manufacturers). An association representing telecommunications interests encouraged the consideration of the impacts of C-ITS on telecommunications providers, and also suggested that other environmental impacts, such as land use and pollution, as well as the wider economic dimension might be considered.

An association representing transport operators noted that the impact of C-ITS on the share of public transport was missing, while two similar associations noted that the impact on shared mobility was not considered. In both cases, this was linked to the lack of a relevant objective for C-ITS in relation to public/shared transport. Another association representing road transport operators (along with similar responses from three cities) noted that C-ITS should not just aim to reduce emissions from individual vehicles, but in sensitive areas, such as in urban environments, which could be achieved by appropriate routing and other interventions in the course of a vehicle’s journey.

It was also suggested, by a city network, that C-ITS has a positive role to play in enforcing traffic rules, including access restrictions and parking management. Two organisations representing consumers underlined the importance of consumer acceptance of C-ITS and suggested that many consumers would expect that the hidden purpose of C-ITS was for it to be used for surveillance. A network of ITS interests underlined that C-ITS enables technology that can be used for networking and automating mobility. An association representing telecommunications interests (and a company) highlighted the importance of viable public-private partnerships in order to make the deployment of connected vehicle technology an appealing investment for authorities and for industry.

The importance of improving the safety and management of level crossings, where roads and railways meet, was highlighted by an association of transport operators. They noted that the rail sector had developed technologies to improve safety at level crossings, which should be taken into account in further consideration of how the data could be used for the benefit of citizens and road users. They were generally in favour of a greater exchange of information between the road and rail sectors to better manage disturbances and generally improve safety using real time and predictive train crossing information.
Responses from private companies mentioned some other impacts that might be missing from the list presented in the online public consultation. An ITS service provider noted that the wider economic value of C-ITS and wider quality of life impacts were not mentioned. A supplier wanted the anticipated positive impact on vulnerable users to be emphasised more, as well as the impact on long haul goods transport. A vehicle manufacturer underlined that the coexistence of different communication technologies that were able to use the 5.9 GHz band of the radio frequency spectrum was important.

An ITS research network noted that the potential benefits of C-ITS would be felt in other sectors, as transport drives digitalisation and automation. An ITS service provider proposed that the benefits for the EU’s Digital Single Market could be incorporated, while also noting that the division of roles between the public and private sector could be given greater consideration. A telecommunications provider suggested that an impact might be increased costs for users, if insurance premiums were to increase as a result of the new C-ITS systems being fitted to cars, which could act as a barrier to adoption.

Some responses from companies were of a more general nature, or were more closely related to impacts that had been listed in Question 17. A consultancy that was sceptical of the need for EU action, proposed that the effort spent on developing the proposed policy framework for C-ITS would be better spent on promoting work on international standards. A supplier noted that it was still not clear who would pay for which parts of the necessary C-ITS system. A consultancy noted that C-ITS could have a beneficial impact on the costs and effectiveness of traffic management, while a telecommunications provider noted that the impacts on congestion and CO₂ emissions were likely to vary between countries. A car rental company and a company involved in the repair and replacing of vehicle parts reiterated the importance of a binding legal framework to guarantee the right to fair access to in-vehicle data for all market operators, including the aftermarket.

In response to the question about impacts that were missing from those listed in Question 17, respondents from public authorities listed various impacts, while some raised issues that they felt had been neglected and others provided general comments. Missing impacts that were proposed by different authorities included:

- Impact on the role and structure of road operators.
- Costs associated with replacing roadside equipment with information transmitted directly to vehicles.
- Social inclusion, as sparsely populated areas would be able to be served by automatic transport systems.

A regional authority noted that, while the impact of C-ITS on traffic flow was marginal, such services should raise consumers’ awareness about the physical infrastructure, which should help to deliver better driving behaviour. Another authority raised a number of issues that they considered were in need of additional consideration including: audit and approval procedures for infrastructure; a legal framework to prevent the transmission of inaccurate or misleading information from infrastructure; and the way in which the information was communicated to the driver. A city authority noted that warning drivers about the presence of potentially vulnerable road users was possible, while another city authority underlined the need to provide more information on C-ITS to road users.

Two city authority authorities (and a citizen) underlined the importance of the intermodal benefits of C-ITS, with the implication that this was not currently recognised. A regional authority noted that currently the need for safe driving distances was a barrier to the more efficient use of capacity, but that C-ITS would not address this problem unless there were obligations on the market to fit C-ITS in cars. Another regional authority highlighted that C-ITS had the potential to increase mobility, so that behavioural change was needed to prevent congestion. A national authority noted that C-ITS was an essential step towards automation.

A national ministry listed a number of issues that it felt were missing from the debate, including the development of automated driving, ‘mobility as a service’, the use of retrofit systems on existing vehicles, the involvement of vulnerable road users and developments in the telecommunications market. Similarly, a national roads office listed: the costs and principles covering the operation, maintenance and updating of new services; principles for backward compatibility; and lifetime issues, including the total costs and benefits, as well as the risks associated with hardware failure.

An NGO respondent noted that the impact on driver comfort was missing, which could be improved by information prior to journeys. Another respondent noted that the benefits of C-ITS deployment would be dependent on the way in which C-ITS devices dealt with non-connected users, while they also...
missed the impact of C-ITS on vehicle use and the consideration of older drivers. An NGO representing cyclists underlined points that they had made previously that the development of C-ITS should be undertaken in the context of its potential role in a wider mobility system that had broader health and environmental objectives. Without such a wider perspective, they were concerned that C-ITS would increase the advantages of private motor vehicles and thus contribute to, rather than help to address, the mobility challenges that many cities were facing. Additionally, the deployment of C-ITS could lead to authorities spending money on C-ITS infrastructure that might be better spent meeting other objectives.

Rather than raising impacts that had been missed, citizens responded with various other responses. One noted that, as the penetration of C-ITS in the vehicle fleet would be slow over the next decade, the impacts would also be limited. They also noted that using 3G/4G equipment in cars would not lead to any additional costs. Another citizen underlined that human behaviour should not be ignored, and that changing this would not be possible with only technology. Another respondent noted that C-ITS was the first step towards citizens having greater trust in automation, while technologies such as platooning should improve the working conditions for drivers of heavy duty vehicles.

Of the respondents that classified themselves as ‘Other’, one implied that a missing impact was the need for increased administration. Another underlined the potential for C-ITS to facilitate multimodality and inter-modality, while a third noted that the spread of C-ITS could be the starting point for the rapid deployment of autonomous cars. The need for a greater consideration of the urban component of C-ITS was raised by one respondent, who highlighted that a commitment to use C-ITS to increase the share of public transport was missing, as was the participation of urban operators and communities in the preparation of the relevant EU legislation and in the standardisation bodies.

**E.3.3.4 Q20. Please indicate your level of agreement with this statement (n=132)**

*“The Commission considers that common specifications for C-ITS will help ensure that progress is made by all actors across the value chain in a consistent and harmonised manner. This in turn is expected to reduce administrative burden and to broaden the C-ITS market and make it more accessible, in particular for Small and Medium Enterprises.”*

From the 132 responses received, 39 (30%) indicated they strongly agreed with the Commission’s statement concerning common specifications for C-ITS in helping progress is made, along with another 64 (48%) stating that they agreed (see Figure E-32). Another 17 respondents (13%) neither agreed nor disagreed while, in comparison, only two respondents (1.5%) stated they disagreed with the statement.

Figure E-32: Response on level of agreement with the statement concerning common specifications for C-ITS in helping ensure progress is made, along with decreasing burdens and increasing accessibility (n=131)

![Response graph]

Figure E-33 highlights that, when disaggregated by stakeholder group, the level of agreement is split approximately equally, with at least 60% of respondents from all stakeholder having agreed or strongly
agreed with the statement, and up to 90% for public authorities. Association respondents were most strongly in agreement with 14 out of 36 (38%) indicating they strongly agreed. Respondents who strongly disagreed were from private companies or associations, however this number was negligible (2-3%).

Figure E-33: Response on level of agreement with the statement concerning common specifications for C-ITS in helping ensure progress is made, along with decreasing burdens and increasing accessibility, by stakeholder group

<table>
<thead>
<tr>
<th>Stakeholder Group</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>No opinion / I don’t know</th>
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</thead>
<tbody>
<tr>
<td>A private company (n=38)</td>
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<td>17</td>
<td>1</td>
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<tr>
<td>An association (n=36)</td>
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<td>12</td>
<td>4</td>
<td>6</td>
<td></td>
<td></td>
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<tr>
<td>A public authority (n=31)</td>
<td>9</td>
<td>19</td>
<td>2</td>
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<td></td>
<td></td>
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E.3.3.5 Q21: Please elaborate on your answer to the previous question (n=71)

Seventy one respondents elaborated on their answer to Question 20. Twenty one responses came from associations, 19 from private companies and 15 from representatives of public authorities. Of the remainder, six each came from NGOs and citizens, while four came from those who classified themselves as ‘other’.

The majority of respondents from associations that elaborated on their response to Question 20 agreed with the Commission’s statement. Of those that strongly agreed, a similar response from two associations representing insurers noted that without standardisation and ‘legally enforced transparency’ small and medium-sized enterprises (SMEs) would be prevented from accessing the C-ITS market, which would then favour the ‘big players’. A network of ITS interests noted that standardised message formats allowed new services to be developed, which opened opportunities for SMEs. An association representing those that traded in automotive parts argued that technical developments based on standards could be implemented more quickly to the benefit of all parties, thus enabling innovation.

Of those associations that only agreed with the statement in Question 20, one representing the bicycle industry raised a similar point that standardisation would benefit all market players, with SMEs benefiting in particular if protocols were set up in a way that did not significantly increase administrative burden. Another association representing telecommunications providers (and a company) referred to a study that suggested that SMEs were expected to play a role in the installation and operation of C-ITS. An association representing transport operators (and similar responses from three cities) noted that standardisation helps to create investment security, while an association representing digital interests underlined that their interpretation of ‘common specifications’ meant technology neutrality. A city network appreciated EU leadership in the development of the policy framework, but noted that it was up to businesses to build a market.
Of those that *neither agreed nor disagreed* with the statement in Question 20, an association representing suppliers noted that standardisation would benefit the entire industry, not SMEs in particular. Two organisations representing consumers provided similar responses, noting that it was not clear whether SMEs would benefit from the C-ITS market; indeed they suggested that it was more likely that manufacturers and tier 1 suppliers would dominate the market. An association representing road operators *strongly disagreed* with the statement arguing that there was a risk of certain statements being taken for granted without there being a wider assessment of the impacts on all of the components of the supply chain.

Of those *private companies* that *strongly agreed* with the statement preceding Question 20, two suppliers highlighted that standardisation provided certainty for investment, while two suggested that otherwise C-ITS would not be deployed in the EU. One of the former noted that standardisation also facilitated the expansion of C-ITS to other vehicles, transport modes and applications. A company involved in the repair and replacing of vehicle parts noted that it was important to consider the entire value chain, and so reiterated a call for a level playing field that provided equal access to connected car data.

A supplier that *agreed* with the statement noted that simplification and market development are two of the benefits that might be expected from standardisation, while another noted that standardisation would bring greater security for the planning of investments. Another supplier noted that standardisation would help to avoid the errors of the past, particularly with respect to there being different road toll collecting systems in different EU Member States, while another underlined that too strict regulation could prove counter-productive. While noting that the administration costs would decline as a result of standardisation, another supplier disagreed that these would decline substantially. A telecommunications provider suggested that standardisation that was driven by industry was more likely to result in harmonised profiles.

Two companies, a telecommunications provider and an ITS service provider, *neither agreed nor disagreed with the statement*, as they were not convinced that standardisation would reduce administrative burden. One even suggested that the increased transparency resulting from standardisation may even put off SMEs from trying to enter the market. A consultancy noted that the statement in Question 20 was dependent on the nature of the specifications that would be put in place, while a supplier noted that a lot was dependent on the action that was taken by Member States. A consultancy that *strongly disagreed* with the statement implied that companies should be left to compete with each other to develop and deliver the most cost-effective solution for particular needs.

A respondent from a *public authority* that *strongly agreed* with the statement suggested that work early on to ensure standardisation would bring added value later, while another noted that only with common specifications would C-ITS be widely deployed. A national roads office noted that their positive response was conditional on the specifications not being too detailed.

Of those public authorities that *agreed* with the statement, a national ministry noted that in principle the statement was correct, but that in practice it depended on the room for innovation and the scope for further development in the value chain, which was crucial in determining the role that SMEs might play. A regional authority noted that SMEs can benefit from government intervention, but that it was important that specifications did not disrupt the market. Two similar responses from city authorities (and a citizen) noted that while standardisation facilitated entry into the market, it reduces the freedom to innovate, although on balance they supported standardisation. A national roads authority noted that common specifications were important to reduce the economic risk associated with investment, while a regional authority made a similar point: that with common specifications, they would invest more quickly. A national transport administration called for a distinction to be made between roadside ITS-G5 and cellular services, as they considered these to be alternatives not complementary, as well as a distinction to be made between services provided commercially and those provided by authorities.

A national ministry *neither agreed nor disagreed* with the statement arguing that while common specifications help progress, when dealing with technological matters they should be flexible and avoid imposing administrative obstacles to the development of technology; hence, they preferred flexible, softer approaches. A city authority *disagreed* with the statement, as it was not convinced that C-ITS would reduce administrative burdens.

All of the *NGO* respondents that elaborated on their response to Question 21 *agreed* with the statement. One noted that common and open specifications would facilitate market entry. Another two were more
cautious, with one noting that this would be the case as long the specifications were not set by the larger industrial players, while the other noted that for the statement to be true the EU would have to ensure the effectiveness of the specifications.

A citizen that agreed with the statement noted that the specifications needed to be future proof and to avoid locking in a particular technology, while another noted that common specifications were a necessary, but not sufficient condition, as success depended on many other factors. A citizen who neither agreed nor disagreed with statement noted that it was not possible for them to have an opinion, as this would depend on the content of the specifications, but that if the latter were future proof and did not lock in a particular technology that they would ‘strongly agree’. Another citizen thought that while making things easier for SMEs would be positive, that these companies would only be bought out by larger companies. A citizen that disagreed with the statement felt that standardisation decisions were generally taken in the interest of the larger companies.

A response from a respondent who categorised themselves as ‘Other’ suggested that common specifications would promote an open market, as long as these were future-proof and technology-neutral, while another underlined that leaving the various stakeholders sufficient room for manoeuvre was important. Another respondent felt that the statement about reduced administrative burden made little sense, as it was not clear to what this was being compared.

**E.3.3.6 Q22. What do you expect to be the main benefits to you / your organisation of substantial deployment of C-ITS? If possible, please include quantifiable examples (n=111)**

“The Commission expects that the deployment of C-ITS will have significant benefits in increasing road safety and reducing congestion. At the same time, it is seen as an important stepping stone towards connected, cooperative and automated mobility, and it will significantly contribute to improved traffic and travel information. As a result, the deployment of C-ITS could considerably influence people’s travel choices in the future.”

There were one hundred and eleven responses to the question asking about the main benefits of C-ITS for the respondents. The majority of these came from associations, private companies and public authorities, which provided 30, 31 and 29 responses respectively. Eight of the remaining responses came from NGOs, six were from citizens and seven came from those who classified themselves as ‘other’.

Several responses from associations set out visions of the potential opportunities that a substantial deployment of C-ITS might bring for their members, and for consumers and society more generally. Two associations (and a company) provided a repeated response that the current periodic technical inspection (PTI) of vehicles would need to be complemented in cars that were capable of ‘highly automated driving’ by a system of automated inspections of on-board systems undertaken by independent organisations. In the longer-term, the electronic systems could be subject to continuous monitoring, although the PTI would still need to check that the vehicle had the right versions of the software.

A repeated response from six associations representing distributors of replacement automotive parts and diagnostic tools (and one private company) noted that the ability to remotely access a vehicle, its data and resources would enable the status of the vehicle to be monitored while it is being driven. This would enable the provision of services, including in-use emissions monitoring and predictive repair and maintenance services. An association representing automotive importers provided a similar response that real-time access to a vehicle’s status would allow the development of services for the consumer.

Two associations representing insurers provided similar responses that drivers could be informed about critical accident risk situations by real-time communication, and thus directly improve the functioning of the vehicle, e.g. emergency braking. They envisaged powered two wheel vehicles and rescue vehicles also being equipped with C-ITS that could prevent accidents, including applications to support turning left and dealing with intersections and curves. An association representing cyclists foresaw the application of 5G-compatible C-ITS in all vehicles, which would enable vehicles to know whether other vehicles or bicycles were coming in their direction, allowing their speed to be automatically adjusted. An association representing the bicycle industry saw C-ITS as enabling improved interaction with two-
and three-wheeled vehicles, thus improving safety and enabling these vehicles to be fully exploited in the context of a low emission, healthy transport system based on the concept of ‘mobility as a service’.

An association representing telecommunications providers noted that LTE connected cars, the numbers of which are continually increasing, would enable the easy roll-out of C-V2X chipsets, which would enable synergies between V2V safety services and area-wide communication. This would enable a range of business models, including ‘infotainment, traffic information, real time mapping and data analytics’, and ultimately lead to fully autonomous cars that would revolutionise transport. Another telecommunications association believed that C-ITS would bring synergies, improve operational efficiencies and facilitate the development of new business models involving different industries. Another association representing telecommunications providers (and a similar response from a company) referred to a report that predicted that self-driving cars would dramatically reduce crashes (and so save countless lives), would enable citizens to be more productive (as they would be able to engage in productive activity in transit) and would deliver growth and jobs.

In the urban context, a city network saw the potential for C-ITS to reduce the costs of managing traffic and enforcing traffic rules in urban areas. Two associations representing public transport operators provided similar responses that argued that C-ITS should become a tool that worked with proper urban and land use planning policies in a wider strategy that promoted shared mobility, otherwise it would not bring any benefits to citizens or public transport operators.

A number of associations focused on the potential benefits of a substantial deployment of C-ITS on society more generally. An association representing vehicle manufacturers (and similar responses from two manufacturers) believed that a large scale deployment of C-ITS, which would come at a cost to manufacturers, would provide investment security that would lead to improved road safety and efficiency. Two consumer associations provided similar responses that C-ITS promised some benefits in road safety, traffic and road network management, comfort and mobility efficiency more generally, although they were not convinced of its business case. A similar organisation highlighted the potential for improvements in safety. Safety improvements were also the main benefit identified by an association representing road operators and two associations representing ITS interests, one of which also highlighted improvements to congestion and air quality, as well as reduced expenditure on infrastructure. An association of transport operators (and similar responses from three cities) highlighted improved safety, particularly at intersections on roads and between road and rail, as well as for cyclists and pedestrians. They also saw benefits from common data formats and the creation of a ‘data chain’.

The focus of other associations was on the benefits of C-ITS for improved efficiency. An association representing logistics interests expected there to be better flows of transport, better use of infrastructure, more real-time information and better enforcement and control as a result of C-ITS. A consumer association foresaw a shift towards networked driving and networked mobility involving all modes of transport. Noting that the motorway network that operated under concession was already smart, an association representing road operators saw C-ITS contributing to the evolution of services and functions that were effective and sustainable from the perspective of costs and benefits.

Various respondents from private companies noted that the benefits of C-ITS to them would be increased sales or increased market opportunities. Such responses were received from companies that provided: security technology for C-ITS; road safety solutions; connectors, antennas and wireless modules; ITS services; V2I instruments; wireless technologies; real-time maps with road conditions; C-ITS cloud servers; satellite communications technology; C-ITS consultancy; C-ITS applications; C-ITS R&D; and repair services enabled by remotely accessing vehicles (as long as this was ensured by an appropriate EU legal framework). A supplier noted more generally that they anticipated increased sales per annum and more jobs.

Others highlighted more general benefits, including better communication channels to road users (a road operator), improved quality of train services through automatic train operation (a rail passenger company) and enabling smart charging devices (a supplier). A manufacturer highlighted that C-ITS, as a result of increased safety and reduced congestion, would bring about more efficient and sustainable transport systems, which was at the core of their business. Another manufacturer noted that the main benefit would be seen in the organisation of traffic, while a supplier suggested that there would be fewer accidents, less disruption to traffic and less congestion, and so more predictability in schedule planning and travel times, as well as new opportunities in the form of automated vehicles and platooning.
The benefits identified by many of the public authorities were in terms of the wider benefits of C-ITS to society. In this respect, 16 public authorities mentioned improved safety, 14 improved efficiency or better management of the road network (including reduced congestion) and seven mentioned benefits in terms of reduced emissions and pollution. Of those that identified improved efficiency as a benefit, three noted that this was due to better information being provided to road users, while a further four identified the provision of better information as a benefit in its own right, with two making a specific reference to better information about particular incidents. A regional authority noted that information would facilitate multimodal and intermodal mobility services, as well as improving the reliability of, and even shortening, delivery times.

A city authority noted that it saw such benefits for all modes of transport, not just for cars, while a national ministry noted that the speed of deployment in the market would be decisive in delivering these benefits. A repeated response from two cities noted that they did not expect C-ITS to deliver reductions in congestion unless it was used along with fiscal or traffic management measures.

Some authorities noted wider, or sometimes more specific, benefits that a significant roll out of C-ITS would bring to them. One national authority noted that C-ITS would facilitate the strategic management of the entire road network, and also that it would contribute to strengthening industry. A regional authority also believed that C-ITS was a first step to the better management of the available infrastructure capacity. A regional authority noted that C-ITS would lead to a wider range of mobility options, but warned that by improving the performance and comfort of car travel, there was a potential risk of modal shift to cars. A national roads authority noted that C-ITS may enable a new platform for infrastructure charging and tolling, as well as supporting the better integration of public and individual transport and ‘mobility as a service’ initiatives. A city authority noted the potential benefits of C-ITS in prioritising certain road users and of warning users about potentially dangerous intersections.

More specific benefits that were noted by public authorities included: facilitating better access to services and activities by those with mobility problems (a city authority); and enabling the reinstatement of bus services, which have disappeared, with automated transport systems (a municipality). A national ministry believed that C-ITS would lower the costs of road maintenance and reduce expenditure on new road infrastructure. Another national ministry argued that for C-ITS to deliver better services at lower cost, it was essential to reuse the existing cellular infrastructure.

Two public authorities identified that a long-term benefit of a significant deployment of C-ITS was high levels of automation in transport, while two authorities highlighted that C-ITS would support ‘better mobility’ more generally. A city authority anticipated that C-ITS would lead to the creation of jobs. On the other hand, two public authorities felt that it was not possible to know what the benefits of C-ITS might be at this stage.

Improved road safety and less congestion or more efficient transport were also mentioned, respectively, by four and two NGO respondents. Additionally, two NGOs foresaw benefits for people with physical or visual disabilities, both in terms of making use of the transport system in general and in terms of access to jobs. On the other hand, an NGO representing motorcyclists was not yet sure of the benefits, but did note that motorcyclists would have different needs from C-ITS compared to other road users. An NGO representing cyclists noted that C-ITS would enable public authorities to control traffic, prioritise active modes and public transport over cars and redirect traffic away from residential and urban areas. They also noted that C-ITS could be used to integrate public bike sharing schemes and electrically-assisted bicycles into the wider mobility system, which could provide data to help public authorities make informed policy decisions. They also reiterated the point that using Intelligent Speed Assistance to limit the speed of cars had the potential for significant road safety benefits and noted that C-ITS could be used for enforcing traffic rules.

Three citizens also mentioned the potential benefits from C-ITS in terms of improved road safety and less congestion/more efficient use of roads. One of these noted that, in the longer-term, C-ITS facilitated automated vehicles. Another noted that there would also be new jobs, improved competitiveness for industry, better traffic monitoring, better responses to incidents and more predictable arrival times. A citizen also noted that potential areas of new research would be opened up.

Four of the responses from those who categorised themselves as ‘Other’ mentioned the benefits of C-ITS on efficiency, three mentioned the impacts on safety and two the environmental benefits. One noted that these benefits were to be expected, along with improved comfort more generally, whereas the benefits from individual C-ITS applications were likely to vary, depending on whether they focused on...
safety, improved efficiency, etc. Another respondent mentioned the substantially increased amount of data about traffic that would become available. Other responses implied that there was a need for more research on the anticipated benefits of C-ITS and underlined that C-ITS had to be used in favour of shared, collective mobility and so be used to change the distribution of modal use in favour of public transport.

**E.3.3.7 Q23. What do you expect to be the main costs and burdens to you / your organisation of substantial deployment of C-ITS? If possible, please include quantifiable examples (n=95)**

There were ninety five responses in response to the question about the potential costs and burdens of C-ITS on the respondents. Twenty four responses came from associations, 26 from private companies and 27 from public authorities. Of the remaining responses, seven came from NGOs, six from citizens and five from those who categorised themselves as ‘other’.

Many associations set out where there would be costs for their members from the substantial deployment of C-ITS. Two associations (and a company) representing vehicle inspection interests noted that investment would be required in the development and validation of new testing procedures and appropriate testing equipment and facilities. A repeated response from six associations representing distributors of replacement automotive parts and diagnostic tools (and one private company) noted that the main additional costs would be for the development of new software applications to provide new services, although they noted that these services had the potential to significantly reduce the logistical requirements associated with the delivery of replacement parts. Similarly, an association representing traders in replacement parts noted that the main costs would be associated with the development of software associated with new services.

An association representing vehicle manufacturers noted that the costs for their members would be high, as a result of the need for increased interoperability and security requirements, particularly the need to ensure that the software for the latter was kept up-to-date. A network of ITS interests implied that the costs of C-ITS would be included in the cost of developing advanced vehicle assistance systems, which would be priced accordingly. An association representing suppliers estimated that the costs would be less than 1% of the turnover related to vehicle production for the first five years, followed by no substantial costs in subsequent years.

An association representing telecommunications providers foresaw the need for significant investments from their sector to ensure that C-ITS was able to function continuously and seamlessly. They highlighted the need to ensure that the possibility of network sharing between telecommunications operators was retained and that the ‘imposition of access obligations must not be weakened’ in order to ensure that solutions could be offered on competitive terms. Another telecommunications association (and a private company) referred to a study that concluded that mandating interoperability between IEEE 802.11p and PC5-based systems would increase costs for in-vehicle equipment as a result of the need to have equipment for both technologies and the need to maintain two radio systems.

A city network identified the main costs as being those associated with the integration of C-ITS into existing traffic management and ITS architecture. An association representing transport operators (and similar responses from two cities) identified a range of costs including: those associated with investing in the necessary roadside devices; upgrading existing systems; and the control and processing of the necessary data. A national association representing road operating companies estimated that the investment needed to implement and maintain the necessary equipment on the roads managed by their members amounted to €600 million between 2018 and 2022, which did not include a 20% increase in costs for maintenance, staff and the renewal of the system. Another, similar association was not able to provide an estimate of costs, but underlined that C-ITS should build on what has been put in place so far and that the process needed to be well-defined, effective and sustainable, both in terms of its costs and impacts. An association representing logistics interests noted that the costs for their members would include investments in vehicles and a contribution to the costs of public investments, either through road charges or other taxation.

Two associations representing insurers did not expect any costs for their members, while an association representing consumers noted that a challenge for C-ITS was ‘last mover advantage’, as some of those involved might wait for others to invest in order to maximise their benefits and minimise their implementation costs.
From the perspective of private companies, two vehicle manufacturers noted that their costs would be affected by the need to ensure interoperability and security, with one emphasising that these would be incurred over the lifetime of the vehicle. A transport operator noted that their costs would be associated with the technical equipment relating to the vehicle and the associated IT equipment. A supplier of C-ITS security services identified their main costs as being those associated with the initial development of the services and the hosting and operation of the services, noting that the latter would incur the majority of the costs. They underlined the need to take account of these potential costs in the development of the legislative framework so as to strike the right balance between costs and benefits. An ITS service provider noted that their IT costs could be significant, while a similar company noted they would be shift to a more service-orientated model, which would require initial investment followed by operational costs. Another ITS service provider noted that their largest cost would be attracting and retaining suitably qualified staff, followed by the cost of obtaining data. A telecommunications provider noted that the costs associated with providing a communication network of sufficient density would be substantial, but that this was only an issue where the case for subsequent financial benefits was not clear. A supplier anticipated that their research costs would increase by more than €20 million a year.

A company involved in the repair and replacement of vehicle parts noted that, without a clear legal framework on access to connected car data (as they had mentioned in previous answers), there would be an extensive burden on their company. A supplier noted that they would expand their company as a result of the substantial deployment of C-ITS, but underlined that this was positive. A supplier raised cost issues around the choice between 802.11p and c-V2X technologies.

A road operator noted that their costs associated with installing roadside equipment had been reduced as a result of their involvement in a C-Roads project, while a supplier noted that there were risks for long-term R&D spending (as a result of intellectual property issues) from the need to work with companies in different sectors. A network of ITS research interests suggested that, as the principles of C-ITS and the necessary design criteria were not fully understood by some of those involved in C-ITS, cost assessments were often inadequate. A consultancy noted that making transport safer would cost money, and that these costs would be passed on to the consumer in some form. On the other hand, a supplier and a telecommunications provider did not expect any substantial costs for their respective companies.

Several responses from public authorities repeated similar anticipated sources of costs, with nine city or regional authorities mentioning roadside equipment, three mentioning the need for investment in central C-ITS equipment and four noting that investment would be needed for the processing of the data. Two cities (and a citizen) highlighted that it was not just about roadside infrastructure for C-ITS, but about ensuring that other roadside signs for communicating with road users were capable of presenting the necessary information, while also noting that the digitalisation of the system should not exclude ‘non-digitalised’ users, such as pedestrians and cyclists. Four authorities explicitly referred to the need to make changes to traffic lights. A regional authority noted that the costs associated with potentially using cellular communication equipment, and also noted that it might be necessary to purchase more detailed traffic data.

A couple of authorities also noted that there would be new roles for public authorities as a result of C-ITS, with the implication that this would need additional qualified personnel. One city authority noted that in order to make the most of C-ITS, there would need to be an increase in computing capabilities, e.g. to forecast the use of the network. A regional authority noted that there would be costs associated with pilot projects and with participating in national and international knowledge networks, while a city authority stressed that there would be a general need to adapt to new regulations.

The main cost identified by national ministries and authorities was in relation to the cost of the roadside equipment, which was mentioned by five of these. Three also mentioned the costs of integrating C-ITS into existing systems, while four identified the development of the necessary central C-ITS systems as a significant cost. One national ministry mentioned the costs associated with upgrading of traffic management systems, while another noted that its main costs would be in relation to the necessary legislation.

One national ministry implied that funding C-ITS infrastructure would be challenging, as the expenditure had not been allocated in the current expenditure plan. Another national ministry noted that the costs would be dependent on the way in which C-ITS were deployed, while a third noted that, apart from the platform, the costs would be very low if C-ITS were based on cellular technology, whereas basing C-
ITS on roadside units would be unaffordable. A national roads administration also noted that they foresaw that 3G and 4G would be used to cover most of their major road network.

From the perspective of NGO respondents, the cost of retrofitting C-ITS into existing vehicles and the costs associated with the provision of information and the education of their members about C-ITS were mentioned. An association representing motorcyclists noted that the costs of C-ITS for their members would be higher, as a result of their particular needs and the smaller number of vehicles over which the costs would be spread.

An NGO representing cycling interests questioned spending limited public resources on more (C-ITS) infrastructure for cars, when the money could be better spent on other measures, including those that prioritise public transport, walking and cycling, which delivered wider benefits. They were concerned that increased reliance by drivers on C-ITS would reduce non-verbal communication between different transport users, which could adversely affect safety in urban areas. They suggested that there were other ways of delivering the benefits that were claimed could be delivered by C-ITS. They also noted that, as deployment was likely to be limited at the start and also that only some actions would be subject to C-ITS, there would be uncertainties about how different road users might change their behaviour as result of C-ITS, which could have negative consequences for safety.

From the perspective of citizens, two mentioned the costs of roadside equipment, with one of these noting that the lifetime of equipment, particularly electronic devices, was often over-estimated. Two suggested that there would be a cost associated with purchasing C-ITS services where industry was not providing these, while two noted that there would be costs associated with fitting C-ITS into vehicles.

A societal cost noted by one respondent was that C-ITS technologies would lead to a ‘dumbing down’ of the skills required for driving and to a greater disregard for those skills.

The responses from those who had categorised themselves as ‘Other’ varied. One noted that the costs associated with roadside equipment, the upgrade and integration needed at central C-ITS stations and the implementation or purchase of C-ITS services when industry did not provide these would all be substantial. One noted the need to contribute to the implementation of the necessary legislation and another that C-ITS would open up new research fields. A public company operating public transport identified a number of costs from their perspective, including: in-vehicle equipment for buses; the modernisation of control centres; the introduction of the necessary communication equipment; and the need to inform drivers and users about C-ITS.

### E.3.4 Additional comments

#### E.3.4.1 Q24. Do you have any additional comments regarding this consultation questionnaire? (n=54)

Fifty four respondents had additional comments on the questionnaire, of which 21 came from associations and 15 from private companies. A further nine responses came from representatives of public authorities, four each from NGOs and those who classified themselves as ‘other’ and only one from a citizen. Many comments did not need to be reflected in this section, as they were inconsequential to the analysis of the views of stakeholders, e.g. thanking the Commission for the opportunity to share their views. Only those responses that provided information of relevance to the analysis are mentioned below.

A number of additional comments from associations reiterated points that they had made in response to previous questions. A similar response from seven associations representing distributors of replacement automotive parts and diagnostic tools (and one private company) believed that C-ITS had the potential to bring significant benefits, but that these would be limited and costs increased, unless there was ‘direct interoperable access to the vehicle, its data and resources via an interoperable, standardised in-vehicle telematics platform’.

An association representing telecommunications providers made reference to two papers (see Section E.4). The first of these, from the GSMA underlined that technology neutrality should be a core principle underlying the development of the ‘European communication framework’, so the Commission should avoid effectively mandating 802.11p as the technology to be used for V2V safety-related services. The second paper, from 5GAA, identified a practical approach to ensure that LTE-V2X and 802.11p were able to coexist in the same band of the radio frequency spectrum. Another similar association (and a private company) underlined the need for a technology neutral regulatory framework for C-ITS, which allowed for the coexistence of C-V2X and IEEE 802.11p in the 5.9GHz band of the radio frequency
spectrum, while facilitating the setting out on the path to use 5G for future connected, cooperative and automated mobility.

An association representing public transport operators stressed that public transport, and shared mobility in a wider sense, should be at the heart of the deployment of C-ITS. They underlined that C-ITS was only a means to an end, and so should be used as part of a wider policy that aims to reduce congestion and pollution. A similar association went further arguing that in a time of limited public resources, C-ITS should not be a priority for public funding. On the other hand, if C-ITS were implemented they argued that it should be used to prioritise public transport.

An association representing vehicle manufacturers (and two manufacturers) noted that the questionnaire should have also covered V2I and I2V, as well as V2V, as it was important that the deployment of equipped vehicles and roadside units was synchronised to deliver better performance, efficiency and return on investments. Two networks of ITS interests noted that it would be important to ensure that research projects do not disrupt the operation of C-ITS applications once manufacturers begin to introduce these on their vehicles. A consumers’ association welcomed the work of the ITS Advisory Group and noted that this should be complemented by a high degree of participation from user associations. An association representing road operators felt that the questionnaire was only a partial reflection of the stakeholders involved in the supply chain, as the role and responsibilities of road managers, as well as the existing systems that were in place, were not given sufficient consideration.

There were fewer additional comments from private companies. A manufacturer noted that a consideration of ‘service bundles’ was important, and suggested that the questionnaire should have focused on Advanced Driver Assistance Systems. A supplier noted that its C-ITS technology was also used in other transport modes, while a consultancy pointed out that the survey did not mention access to vehicle data by third parties. A car rental company noted that it had jointly developed a paper that contained a set of principles and use cases, as well as a proposal to ensure ‘secure, direct, real-time, interoperable and open access to in-vehicle for all third-parties through a neutral car platform’ (see Section E.4). A company involved in the repair and replacement of vehicle parts again called for a ‘clear legal framework on access to connected car data now and in the future’.

From the perspective of public authorities, a national ministry reiterated a point that it had made in response to previous questions. This was that vehicle manufacturers were currently evaluating two possible technologies for providing C-ITS and so any legislative framework needed to be as technologically neutral as possible in order to allow the coexistence of these two technologies, at least in the short-term. In this respect, they noted that the US had not yet implemented its decision to make 802.11 equipment mandatory and that China was focusing on a cellular solution. Another national ministry made reference to an additional paper that it had submitted (see Section E.4). A national roads authority felt that the questionnaire could have had a more explicit mention of freight, as well as more on the cooperation needed between different stakeholders. A city authority noted that it felt that the questionnaire was not always clear about what it was asking about.

An NGO underlined that it should be remembered that there will always be unconnected road users in additional to connected vehicles. Two of the respondents that classified themselves as ‘Other’ underlined that the questionnaire did not cover the role and importance of public transport in C-ITS. One noted that C-ITS should give priority to public transport, and to shared mobility more generally. The other reflected responses from other public transport operators and associations in response to previous questions. They called for the greater consideration of the urban environment in the C-ITS debate, which should be used to increase the modal share of public transport, and the greater involvement of urban interests in the development of the C-ITS legislative framework and in the relevant standardisation bodies. At the same time, they emphasised: the need to maintain freedom of action at the local level; that there should be a basic level of common open standards; that there should be no overly prescriptive top-down requirements affecting urban areas; that there should not be an excessive financial burden placed on operators when deploying C-ITS; and that EU funds should be used to support such implementation.
E.4 Analysis and summary of Ad Hoc responses

In addition to their responses to the questions included in the online public consultation, a number of stakeholders uploaded, or made reference to, additional documents. These are summarised in this section, starting with the additional documents provided by associations, followed by those provided by private companies, public authorities, NGOs and those who categorised themselves as ‘Other’.

Various additional documents were submitted by associations, many of which supported themes that had been raised in response to previous questions. A report produced for the European Commission by TRL\(^2\) was referred to by various associations, including EGEA (European Garage Equipment Association), FIGIEFA (European Federation of Independent Distributors of Automotive Replacement Parts and Components and Insurance Europe), as well as some companies. They referred to this report, as well as to the outputs of the OVERSEE project\(^3\), to call for legislation to ensure access to in-vehicle data. Additionally, Enterprise provided a paper in which they set out some key principles for different use cases that they saw as important to ensure fair access to in-vehicle data for third parties\(^4\), which also referred to the TRL report.

The Gesamtverband Autoteile-Handel (GVA), an industry association representing the independent automotive parts wholesale trade in Germany, had similar concerns. It submitted its response to a Green Paper on ‘Digital Platforms’ that was prepared by Germany’s Federal Ministry for Economic Affairs and Energy\(^5\). While recognising that C-ITS had the potential to bring significant benefits, the GVA underlined the need for their members to have direct access to the vehicle, its data and resources, through an interoperable, standardised in-vehicle telematics platform.

Another German association, the Association of Technical Inspection Agencies (VdTÜV e.V.), submitted its own paper on ensuring safe and secure automated driving\(^6\). They underlined that the rules governing digitally connected vehicles should be harmonised in order to provide legal certainty for drivers. They highlighted that data relating to the vehicle and vehicle owner must be protected, yet the digital interfaces should provide secure, open and interoperable access for all market players. Further, they noted that the way in which connected vehicles were tested as part of type approval, but also in periodic inspections throughout their lifetime, must be continually developed, and drivers must be trained to use the new systems.

The European vehicle manufacturers association, ACEA, provided its position paper on how access to in-vehicle data could occur for third party services in a way that it considered to be fair, while striking a balance between the needs of the various actors involved\(^7\). ACEA also referred to two reports, which identified, and estimated the impacts in terms of reduced CO\(_2\) emissions, of ITS that might be used for passenger cars\(^8\) and commercial vehicles\(^9\).

A report by Analysys Mason and SBD Automotive\(^10\), which was produced for the 5GAA, an association that represents telecommunications providers, was referred to by several similar associations, a company and a national ministry. The benefits of the respective scenarios developed in the report were cited as evidence in support of the use of cellular technology for V2X communication, or at least a technology neutral approach that allowed this technology to coexist with the technology based on IEEE 802.11p. In support of the same conclusion, a separate report from 5GAA concluded that the cellular LTE-V2X (PC5) would be better than 802.11p at reducing accidents\(^11\). This report also concluded that requiring the former technology to be backward compatible with the latter would risk distorting the market in favour of the latter and deliver limited benefits. An additional paper from 5GAA set out the case for cellular V2X (PC5) compared to 802.11p, and the benefits for different stakeholders\(^12\). A report from the GSMA, another association representing telecommunications providers, made similar points\(^13\).

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\(^2\) TRL (2017) “Access to In-vehicle Data and Resources”, report for European Commission DG Mobility and Transport
\(^3\) https://www.oversee-project.com/index.html
\(^4\) Enterprise (2017) “The Future Mobility System: Technical solution and key principles to ensure fair access to in-vehicle data for all third parties”
\(^7\) ACEA (2016) “Position Paper: Access to vehicle data for third party services”
\(^10\) Analysys Mason and SBD Automotive (2017) “Socio-Economic Benefits of Cellular V2X”, report for 5GAA
\(^11\) 5GAA (2017) “An assessment of LTE-V2X (PC5) and 802.11p direct communications technologies for improved road safety in the EU”
\(^12\) 5GAA (no date) “The Case for Cellular V2X for Safety and Cooperative Driving”
\(^13\) GSMA (2018) “Safer and Smarter Driving: The Rollout of Cellular V2X Services in Europe”
The European Competitive Telecommunications Association (ECTA) submitted three reports. The first was a report from the Body of European Regulators for Electronic Communications (BEREC) and the Radio Spectrum Policy Group (RSPG) on facilitating mobile connectivity in challenging areas. The second was the ECTA’s response to the initial BEREC/RSPG consultation, while the third was the ECTA’s response to a more recent RSPG consultation on a roadmap towards 5G for Europe. The first two illustrated the various technical aspects of ensuring connectivity in difficult situations and underlined the importance of taking account of competitive considerations and of ensuring that connectivity can be consistently provided for the maximum benefit of society. The third report provided insights on how the next generation of wireless communications technology should be introduced, including in relation to C-ITS, in order to ensure that competition continues to contribute to delivering the anticipated benefits.

A position paper from EUPAVE, the European Concrete Paving Association, set out its view of the role of connected, autonomous and electric vehicles and the role its members could play in supporting these developments, including in the context of C-ITS. CONEBI, the Confederation of the European Bicycle Industries, referred to the EU Cycling Strategy, which it developed along with other cycling stakeholders. This included a chapter dedicated to Multimodality and Intelligent Transport Systems, as well as electrically assisted bicycles, which were mentioned by some stakeholders in their responses.

The city network Polis underlined that there were many challenges for cities in relation to C-ITS. It noted that the nature of the problems relating to improving road safety and the efficiency of the use of the road network in cities were very different from those that existed on motorways. This was a particular challenge in relation to C-ITS, as many of the latter have been developed for the inter-urban, rather than the urban road network. It submitted reports from two projects, CIMEC and CODECS, which set out in more detail these and other challenges for cities in relation to C-ITS.

The Union des Transports Publics et Ferroviaires (UTP), the organisation that represents French public transport interests, submitted an additional contribution. In their submission, while supporting the deployment of C-ITS, they argued that C-ITS should be used to prioritise public transport and act as a catalyst for increasing shared mobility, which should be promoted by the legal framework being developed by the Commission. Consequently, they deplored the lack of reference to public transport in the consultation, noting that operators with autonomous metros would be able to inform the debate, and called for the inclusion of public transport stakeholders in the debate about C-ITS at the European level.

The Verbraucherzentrale Bundesverband (VZBV), representing German consumer organisations, submitted a paper that it had produced in response to a study in Germany on the use of data in the transport system. This underlined that privacy for consumers and innovation in C-ITS must be reconciled, and that data protection should be seen as a ‘building block in the value chain of digital business models’. They also highlighted that the socially-responsible use of the data must be ensured, to make up for the imbalance in the contractual relationship between consumers and businesses.

The Associazione Italiana Società Concessionarie Autostrade e Trafori (AISCAT), an association representing Italian road operators, submitted a paper that it had prepared in response to a ‘smart road’ initiative undertaken by the Italian Ministry of Infrastructure and Transport. The paper underlined that, when talking about ‘smart roads’, it was important to make a clear differentiation between different types of road. In this respect, they underlined that the motorway network in Italy was already well structured and well managed, which should be taken into account in the development of the relevant policy.

Submissions from private companies were also submitted in support of issues mentioned in the rest of the consultation. Intel submitted the 5GAA reports mentioned above, along with many links and its own paper, which provided a set of policy principles for connected vehicles. These underlined that innovation and market competition, rather than regulation, should drive public policy in this area; that

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15 ECTA (2017) “Response to the public consultation by BEREC and RSPG on the draft BEREC and RSPG ‘Joint report on ‘Facilitating mobile connectivity in “challenge areas”’”
17 EUPAVE (2016) “Connected, Autonomous and Electric Vehicles: Concrete infrastructure can pave the way”
19 CIMEC (2017) ‘C-ITS in European cities: The CIMEC project – Experience and Recommendations’
20 CODECS (2016) “Requirements of urban transport authorities regarding cooperative V2I and V2V systems and their strategic policy implications”, Project Deliverable 4.2
22 Verbraucherzentrale Bundesverband (2017) ‘Verbraucher als ‘Eigentümer’ von Mobilitätsdaten?’ (Consumers as ‘owners’ of mobility data?)
24 Intel (no date) “The Internet of Things (IoT) and Automotive & Transport Policy Principles”
the focus should be on increasing the safety of transport; that there should be open standards; and underlined the need for viable partnerships between the public and private sectors.

Siemens attached three documents, the first of which was a joint paper with NXP Semiconductors and Cohda Wireless, setting out the case for 802.11p, as opposed to LTE and 5G, for V2X communications. This underlined that the former was ready to be deployed and argued that, unlike cellular technologies, it was able to address the most challenging V2X use cases. The other two documents were press releases, the first of which announced the publication by the C-Roads Platform of C-ITS specifications for Europe, while the second was the C-Roads Platform’s position paper on the use of the 5.9 GHz band of the radio frequency spectrum. The latter underlined that there should be interoperability between ITS-G5 / 802.11p and LTE-V2X / 5G and that road authorities should not be forced to equip their roads with two or more competing technologies. Additionally, it stated that the platform’s members were committed to ‘backwards compatibility’ criteria.

Autotalks submitted two documents, both of which focused on ITS-G5 technology based on the wireless standard 802.11p. The first was a letter to the US authorities, signed by Autotalks and many other stakeholders, while the second was a statement relating to EU policy, which was signed by Autotalks and other companies. Both argued that ITS-G5/802.11p (or DSRC in the US) was the only validated technology on the market capable of being used for C-ITS and that any other technologies operating in the 5.9 GHz band of the radio frequency spectrum should not interfere with each other, be interoperable and be able to co-exist with communications in the 5.8 GHz band.

HERE B.V. submitted a copy of the final evaluation report of the NordicWay C-Roads project, which was also referred to be Ericsson. It was underlined that this project demonstrated the potential for good results from C-ITS with only limited investment, when existing cellular infrastructure was used for the purpose of communication. Centaur Consulting Ltd submitted the final report of the CIMEC project, the focus of which was the implementation of C-ITS in cities, a project that was also referred to by Polis (see above). NIRA submitted a presentation that provided an introduction to their company.

Some public authorities submitted additional documentation directly addressing the consultation, while others provided reports that are of a more general interest. The French authorities submitted a note to complement their response to the online public consultation. This underlined a number of issues on which a European intervention on C-ITS should focus. They underlined that the EU policy framework should focus on interoperability in order to ensure the consistent use of C-ITS in all Member States and that it should facilitate the deployment of C-ITS through technological and functional considerations, rather than being prescriptive. Additionally, EU policy should address the issue of on-board equipment and data access arrangements in order to ensure a smooth functioning of the internal market, while also guaranteeing the protection of personal data and promoting research.

The Dutch authorities submitted two documents: a direct response to the consultation and a call for innovation partnerships in the context of their ‘Talking Traffic’ partnership. The former complemented their responses to the online public consultation. It underlined the importance of C-ITS for the future of road transport, but noted that it was important to distinguish between use cases, as the respective functional requirements will determine the optimal communication technology. In this respect, they supported a technology-neutral hybrid communication approach, which did not give preference or priority to a particular communications technology. Their position was informed by a recognition that it was possible to make better use of the existing cellular 4G LTE networks, while the further development of direct cellular communication (C-V2X) and 5G in the longer-term was considered to be interesting. They underlined the importance of a joint coordinated approach at the EU level to agree on technical standards and profiles for interoperability and continuity of services across national borders.

25 Bundesministeriums für Wirtschaft und Energie
26 C-Roads Platform (no date) “The C-Roads Platform publishes harmonised C-ITS specifications for Europe”
27 C-Roads Platform (no date) “Radio frequencies designated for enhanced road safety in Europe - C-Roads position on the usage of the 5.9 GHz band”
29 SINTEF (2017) “Final project report - CIMEC deliverable D5.3”
30 NIRA Dynamics AB (no date) “Together for Smarter Safety”
31 Note des autorités françaises (2017) “Contribution des autorités françaises à la consultation sur des spécifications pour des systèmes de transport intelligents coopératifs (STI-C)”
32 “Inbreng Nederland in EC consultatie”
33 Ministry of Infrastructure and the Environment (2016) “All for Innovation Partnerships for smarter and inter-urban mobility through intelligent services”

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Furthermore, they underlined that privacy and security, as well as a realistic testing of applications, would need to be addressed before C-ITS could be implemented on a large scale.

The Ministry of Transport and Communications of Finland underlined the need to create an operational framework to support the use of automation, the utilisation of data and new mobility services to their fullest potential. However, they noted that in doing so deregulation and the need to reduce administrative burden should be retained as high priorities, so they had a preference for soft measures and industry standards as far as was possible. In relation to interoperability, they noted that clear minimum requirements were a necessity for the deployment of C-ITS, but argued against their mandatory introduction at this stage, preferring for a principle of interoperability to be agreed upon and implemented at the most appropriate level. They also noted that interoperability should not only be seen as an internal issue for C-ITS services, but also applied more broadly to include relevant infrastructure and other ‘Internet of Things’ systems, including smart city features. While recognising that a high level of security was critical and supporting a common EU framework, the Finnish Transport Ministry called for existing validated solutions and legal instruments (such as the proposed cyber security Regulation that is under discussion) to be taken into account when assessing the need for further legislation. In relation to privacy and data protection, they noted that rules relating to personal data processing should only be included in C-ITS specific legislation where they were needed to complement the GDPR, the relevant principles of which could be included in recitals of the proposed C-ITS Regulation. Finally, they argued that no mandate or other requirements relating to communications technologies should be included in the proposed Delegated Act.

The Portuguese Public Authority for Mobility and Transport (AMT) provided a direct response to the Commission’s consultation. They agreed that the implementation of C-ITS could be hindered by the lack of guidelines and a clear framework, as otherwise there was risk of a lack of interoperability that would prevent the benefits from being delivered. This should be addressed by future EU legislation in this area, which should ensure EU-level compliance, although this could include a soft approach, e.g. including guidelines. They underlined that it was important to consider the effects of the different options in terms of all their potential benefits, and to also understand all of the potential financial and economic impacts. The definition of minimum and overarching parameters should promote industrial innovation and allow consumers to make choices, while the regulator provided effective oversight of the market. They believed that any future change to the EU legal framework should involve open specifications that ensure the exchange and re-use of data in a transparent, neutral and non-discriminatory way and to ensure effective interoperability based on common rules and interoperable solutions. The protection of privacy and personal data was also a crucial factor for the successful implementation of C-ITS.

The Austrian Ministry for Transport, Technology and Innovation submitted its national C-ITS Strategy and also referred to the C-ITS corridor that is being developed to link Vienna with Rotterdam in the Netherlands, via the German city of Frankfurt. The submission from Vienna City Council provided information on the structure of transport in the city, and its financing. The German city authorities of Munich, Hamburg and Cologne submitted a report outlining the opportunities and challenges for municipalities from C-ITS. In addition, the city authority of Cologne, as well as that of Kassel, submitted a guide for public authorities on establishing C-ITS. The Swiss Federal Roads Office referred to a report from the Swiss Federal Council on the implications of automated driving for transport, which underlined that C-ITS would only contribute to reductions in congestion and CO₂ emissions if it was accompanied by further measures to ensure that excessive increases of traffic were not generated.

Two NGOs submitted reports published by the European Transport Safety Council (ETSC), one of which was submitted by the European Cyclists’ Federation and the other by the ETSC itself. The first of these set out the potential safety benefits and challenges of C-ITS, and concluded with some recommendations for both the EU and Member State level. It recommended that the priority should be on those C-ITS that improve safety and underlined that there was a need to make appropriate changes to both legislation governing vehicle type approval and roadworthiness testing. Other recommendations

34 AMT (2018) “Consulta Pública sobre Sistemas Cooperativos de Transporte Inteligentes”
36 Stadt Wien (no date) “Verkehrssicherung”
37 Wegweiser des OCA Aawk IWS (no date) “Kooperative intelligente Verkehrssysteme: Chancen und Herausforderungen für die Kommunen”
38 Technische Universität München et al (2016) “Leitfaden für die Einrichtung kooperativer Systeme auf öffentlicher Seite”
underlined: the need to define, and clarify access rights, to the information needed for ‘highly automated driving’; the need for clear human-machine interfaces; and the importance of providing relevant information to consumers. The second paper covered similar issues, but with more detail in relation to their relevance to C-ITS. A report analysing the cost-effectiveness of measures and features that could be implemented to improve vehicle safety in the EU was also submitted. The German Road Safety Council (DVR) submitted two of its own reports. The first of these made a series of recommendations relating to ‘automated driving functions’, including that the driving behaviour of these systems should not be different from that expected by human beings and that each system must be approved on an individual basis. The second focused on improving road safety due to V2X communication. This underlined that data privacy and security must be ensured, and proposed a set of requirements for the communication technologies that were used. It also underlined that: safety applications should not be restricted to cars; that the deployment of the relevant technologies should happen as quickly as possible; and that Euro NCAP should include V2X technology in its safety rating scheme.

A number of additional documents were supplied by those who categorised themselves as ‘Other’. A group of road authorities and operators cooperating within the European ITS Platform, who submitted a joint responses to the consultation, submitted one report from the Easy Way project, and referenced a report from the EIP+ project. The former presented a business case and cost-benefit assessment of the priority C-ITS considered by the project. The second underlined that, as a result of actions by road operators, C-ITS services contribute to improved road safety, traffic efficiency and environmental protection. A researcher from Eindhoven University of Technology also submitted two papers, both of which provided examples of business models for C-ITS.

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42 TRL (2017) “In-depth cost-effectiveness analysis of the identified measures and features regarding the way forward for EU vehicle safety”, report for European Commission DG Internal Market
43 DVR (2017) “Automated Driving Functions”

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E.5 Glossary/Acronyms

- **ACEA** – European Automobile Manufacturers Association
- **ADAS** – Advanced Driver-Assistance Systems
- **AISCAT** – The Associazione Italiana Società Concessionarie Autostrade e Trafori
- **AMT** – The Portuguese Public Authority for Mobility and Transport
- **BEREC** – The Body of European Regulators for Electronic Communications
- **CEN** – The European Committee for Standardization
- **CEPT** – The European Conference of Postal and Telecommunications Administrations
- **C-ITS** – Cooperative Intelligent Transport Systems - the use of technologies that allow road vehicles to communicate with other vehicles, with traffic signals and roadside infrastructure as well as with other road users. The systems are also known as vehicle-to-vehicle communications, or vehicle-to-infrastructure communications.
- **C-ITS Platform** – A platform developed by the European Commission (DG MOVE) in November 2014 to support the emergence of a common vision across all actors involved in the value chain in terms of the interoperable deployment of C-ITS systems in the EU.
- **CIMEC Project** – Cooperative ITS for Mobility in European Cities
- **CIVITAS** – City VITAlity and Sustainability – a network of cities for cities dedicated to cleaner, better transport in Europe and beyond.
- **C-ROADS Platform** – a joint initiative of European Member States and road operators for testing and implementing C-ITS services in light of cross-border harmonisation and interoperability.
- **C-V2X** – Cellular V2X (5G)
- **DSRC** – Dedicated short range communication
- **DVR** – The German Road Safety Council
- **EATA Roundtable** – The European Automotive Telecom Alliance roundtable meeting
- **ECTA** – The European Competitive Telecommunications Association
- **EGEA** – European Garage Equipment Association
- **ETSC** – The European Transport Safety Council
- **ETSI** – The European Telecommunications Standards Institute
- **EUPAVE** – The European Concrete Paving Association
- **Euro NCAP** – The European New Car Assessment Programme
- **EU-13 Countries** – Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovak Republic, Slovenia
- **EU-15 Countries** – Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden, United Kingdom
- **FIGIERFA** – European Federation of Independent Distributors of Automotive Replacement Parts and Components and Insurance Europe
- **GDPR** – General Data Protection Regulation
- **GEAR2030** – a high level group on automotive industry which has analysed and discussed the key trends and challenges which will affect the automotive industry over the next 15 years.
- **GMSA** - GSM Association - a trade body that represents the interests of mobile network operators worldwide
- **GVA** – The Gesamtverband Autoteile-Handel
- **HORIZON 2020** – the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness.
- **IEEE 802.11p** – a wireless vehicle communication system
- **ISA** – Intelligent Speed Assistance - any system that ensures that vehicle speed does not exceed a safe or legally enforced speed.
• ‘IP-based’ communication networks – Internet Protocol
• ITS – Intelligent Transport Systems - systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport
• LTE-V – LTE-Vehicle technology
• MaaS – Mobility as a Service - brings every kind of transport together into a single intuitive mobile app
• NGO – Non-governmental organisation
• NordicWay – a pilot project that seeks to enable vehicles to communicate safety hazards through cellular networks on a road corridor through Finland, Norway, Sweden and Denmark.
• OEMs – Original equipment manufacturers
• OVERSEE Project – a European research project, funded within the 7th Framework Programme of the European Commission, to contribute to the efficiency and safety of road transport
• PC – Public consultation
• PTI – Periodic technical inspection
• RSPG – Radio Spectrum Policy Group
• SMEs – Small and Medium-sized enterprises
• Trans-European road network (TERN) – a project to improve the internal road infrastructure of the EU
• UTP – The Union des Transports Publics et Ferroviaires
• VZBV – The Verbraucherzentrale Bundesverband
• V2I – Vehicle to Infrastructure
• V2V – Vehicle to Vehicle
• V2X – Vehicle-to-everything (V2V or V2I) communication is the passing of information from a vehicle to any entity that may affect the vehicle, and vice versa.
• 5GAA – 5G Automotive Association
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Annex F – List of European C-ITS Deployment Projects
Report for DG MOVE

Customer: DG MOVE


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Approved By: Sujith Kollamthodi

Date: 25th May 2018

Ricardo reference: Ref: ED10644  Issue number 1

In November 2012, Ricardo plc acquired the assets and goodwill of AEA Technology plc and formed a new company, Ricardo-AEA Ltd. The entire capability and resources previously represented by AEA Technology plc were transferred to Ricardo-AEA, as were all employees. Consequently, where specific projects or track record referenced in this proposal were undertaken and completed prior to the acquisition, for contractual reasons, these continue to be identified as AEA Technology plc.
## ANNEX F – LIST OF EUROPEAN C-ITS DEPLOYMENT PROJECTS

<table>
<thead>
<tr>
<th>Project</th>
<th>Dates</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AdaptIVe</td>
<td>2014-2017</td>
<td>Complete</td>
<td>AdaptIVe stands for &quot;Automated Driving Applications and Technologies for Intelligent Vehicles&quot;. AdaptIVe targets an ideal interaction between drivers and automated systems by using advanced sensors, cooperative vehicle technologies and integrated strategies. The level of automation dynamically adapts to the situation and driver status.</td>
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<tr>
<td>Aktiv</td>
<td>2006-2010</td>
<td>Complete</td>
<td>Aktiv stands for &quot;Adaptive and Cooperative Technologies for the Intelligent Traffic&quot;. This German research initiative brings together 29 partners - automobile manufacturers and suppliers, electronic, telecommunication and software companies as well as research institutions. With the goal of improving both traffic safety and traffic flow in the future, the partners are working together to design, develop, and evaluate novel driver assistance systems, knowledge and information technologies, solutions for efficient traffic management and C2C and C2I communication for future cooperative vehicle applications. The initiative Aktiv consists of 3 projects: Traffic Management, Active Safety and Cooperative Cars (+CoCarX).</td>
</tr>
<tr>
<td>Autopilot</td>
<td>2017-2019</td>
<td>On-going</td>
<td>Enhance the driving environment perception with IoT sensors enabling safer highly automated driving; Foster innovation in automotive, IoT and mobility services; Use and evaluate advanced vehicle-to-everything (V2X) connectivity technologies; Involve Users, Public Services, Business Players to assess the IoT socio-economic benefits; Contribute to the IoT Standardisation and eco-system.</td>
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</table>
| BaSIC   | 2012-2013   | Complete   | Funded by the Czech Technology Agency. Road type: Motorways. Proof of concept for various services including reduced speed limit, roadworks warning, emergency vehicle approaching warning. The deployment of Cooperative ITS through the BaSIC project allowed the road operators to prepare for the new technologies and related installations on road side.  

2 year national real demonstration project for C-ITS, focussed on V2I and V2V. Two applications were selected for the trial on a section of Prague Ring Road between motorways D1 (Prague-Brno-Ostrava), D5 (Prague-Pilsen), and D8 (Prague-Dresden). The trial used VMS (Variable Message Signs), which were displayed to the driver on a screen in the vehicle. The first application (reduced speed limit) informed drivers of a speed reduction from 130km/h to 120km/h, and warned of road works and maintenance vehicles travelling slowly ahead. The second application (emergency vehicle approaching) informed drivers about emergency vehicles on a mission.  

For V2I and V2V communications, the project used 802.11p and 802.11g networks and the standardised protocols DENM, CAM and FSAP. |
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<tr>
<th>Project</th>
<th>Dates</th>
<th>Status</th>
<th>Description</th>
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<tbody>
<tr>
<td>Brabant In-Car II: ParckR</td>
<td>2011-2012</td>
<td>Complete</td>
<td>Trial of the Parckr, Intelligent truck parking app. The Parckr Android app gives you an overview of all truck parking areas along your route. Per truck parking area, it indicates the expected occupancy at your time of arrival, as well as useful information on facilities. It also shows you what other truck drivers think of a particular truck parking area. Parckr is the first community for truck drivers to share information on truck parking areas, and the first smartphone app to predict occupancy rates for truck parking areas. From July to November 2012 Parckr will be trialled on the corridor Rotterdam – Venlo.</td>
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<tr>
<td>CCC</td>
<td>2010-2013</td>
<td>Complete</td>
<td>Connected Cruise Control (CCC) is a breakthrough application in this direction. It provides an advice to the driver regarding speed, headway and lane in order to anticipate to and eventually prevent congestion. It is based on the integration of in-vehicle systems and roadside algorithms for traffic flow improvement. As a first step it can be introduced as a retrofit nomadic device. In this way it can rapidly gain a substantial penetration rate and provide a foundation for OEM fitted systems with active vehicle control. The different stages of the project: 2010: Develop architecture, in-car and road-side platform 2010-2011: Basic research data fusion, traffic flow improvement, HMI 2012: Testing, evaluation (2012-2013: Product development)</td>
</tr>
<tr>
<td>CIMEC</td>
<td>2015-2017</td>
<td>Complete</td>
<td>A coordination and support activity to facilitate the take-up of C-ITS in European cities. It aims to align technological solutions with user needs to reduce barrier and risk in deployment.</td>
</tr>
<tr>
<td>C-ITS Deployment Corridor NL-DE-AT</td>
<td>2013-2017</td>
<td>Complete</td>
<td>Cooperative ITS Corridor Rotterdam – Frankfurt/M. – Vienna. It is planned that the roadside cooperative ITS infrastructure for the initial services in the Cooperative ITS Corridor Rotterdam – Frankfurt/M. – Vienna will be installed by 2015. The EU Member States the Netherlands, Germany and Austria have signed a Memorandum of Understanding to realise this new technology in close cooperation. The deployment of the corridor has been agreed with industry. They will bring the first vehicles and telematic infrastructure onto the market also starting 2015. Concrete declarations of intent were already signed by the parties involved or are in preparation. Two cooperative ITS services are first planned for use in the Cooperative ITS Corridor Rotterdam – Frankfurt/M. – Vienna: Roadworks warning (RWW) and Probe Vehicle Data (PVD). In both cases, communication from the vehicle and infrastructure is established via short range communication (Wi-Fi 802.11p, 5.9GHz) or the cellular network (3G, 4G). Both initial applications increase road safety and provide the basis for an improved traffic flow. The Austrian section of this project is referred to as ECo-AT.</td>
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<tr>
<td>Project</td>
<td>Dates</td>
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<tr>
<td>City2.e 2.0</td>
<td>2014-2015</td>
<td>Complete</td>
<td>City2.e 2.0 is supposed to contribute to the turnaround in energy and traffic policy. The main objective is a practical demonstration of an intelligent parking space monitoring and control - including electrical car charging facilities. Main parts are a prototype of a holistic parking detection, a practical real-world test, and a system architecture for monitoring and control of detected parking spaces. The developed solution is to be integrated in the Berlin traffic information system. The DFKI develops an adaptive prediction solution using machine learning methods to give estimations of future parking area occupation. Thereby, an improvement of planning, routing, and usage of parking spaces and charging stations could be realized. Supported by the (German) Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (grant no. 16EM2051-5)</td>
</tr>
<tr>
<td>C-Mobile</td>
<td>2017-2020</td>
<td>On-going</td>
<td>C-MobILE is deploying C-ITS services designed to deal with specific mobility challenges across Europe. The project also aims to help local authorities deploy the C-ITS services they need and to raise awareness of the potential benefits for all road users.</td>
</tr>
<tr>
<td>COBRA</td>
<td>2011-2013</td>
<td>Complete</td>
<td>COoperative Benefits for Road Authorities a research project of the cross-border funded joint research programme &quot;ENR2011 MOBILITY – Getting the most out of Intelligent Infrastructure&quot;. The Project aimed to aid road authorities in optimally benefiting from changes in the field of cooperative systems (CS). This was done by providing an insight on the costs and benefits of possible investments, both from a societal and business case perspective. The main outcome was a decision support tool, which enables the costs and benefits of the three bundles of cooperative services to be compared in various contexts, to support road administrations on investment decisions under different deployment scenarios.</td>
</tr>
<tr>
<td>CoCAR</td>
<td>2006-2009</td>
<td>Complete</td>
<td>Part of the Aktiv project, the CoCar project is aiming at basic research for C2C and C2I communication for future cooperative vehicle applications using cellular mobile communication technologies. Five partners out of the telecommunications- and automotive industry develop platform independent communication protocols and innovative system components. They will be prototyped, implemented and validated in selected applications. Innovation perspectives and potential future network enhancements of cellular systems for supporting cooperative, intelligent vehicles will be identified and demonstrated. Funded by BMBF.</td>
</tr>
<tr>
<td>CoCarX</td>
<td>2009-2011</td>
<td>Complete</td>
<td>CoCarX is the extension to the CoCar project as part of the Aktiv initiative. It is formed of partners Bundesanstalt fur Straßenwesen, Ericsson, Ford Forschungszentrum Aachen, Vodafone D2 and Vodafone Group R&amp;D who examine the next generation of mobile technologies for the C2X communication goal. This includes a real world trial of C-ITS services using 4G LTE technology at 2.6GHz and extends to direct wireless (using 802.11p, named pWLAN by the team), creating a more complex system than in CoCAR. The differences between CoCAR and CoCarX include: LTE further improvements (car-to-car delay times below 100ms), further network capacity and broadband coverage, heterogeneous communication system with pWLAN and LTE, multi-service capabilities and differentiated billing (priority messages, etc) and enhanced data and service management. Funded by BMBF.</td>
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<tr>
<td>Project</td>
<td>Dates</td>
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<tr>
<td>CO-cities</td>
<td>2012-2013</td>
<td>Complete</td>
<td>Co-Cities is a pilot project to introduce and validate cooperative mobility services in cities and urban areas. It will develop a dynamic ‘feedback loop’ from mobile users and travellers to the cities' traffic management centres, and add elements of cooperative mobility to traffic information services. These software extensions are based on the In-Time Commonly Agreed Interface (CAI), and the pilots will be run in the cities of Bilbao, Florence, Munich, Prague, Reading, and Vienna.</td>
</tr>
<tr>
<td>CODECS</td>
<td>2015-2018</td>
<td>On-going</td>
<td>CODECS acts as a nodal point pooling stakeholders involved in C-ITS deployment in the consecutive implementation phases.</td>
</tr>
<tr>
<td>CODIA</td>
<td>2007-2008</td>
<td>Complete</td>
<td>CODIA (Co-Operative Systems Deployment Impact Assessment) aimed to provide an independent assessment of direct and indirect impacts, costs and benefits of five co-operative systems: Speed adaptation due to weather conditions, obstacles or congestion (V2I and I2V communication), Reversible lanes due to traffic flow (V2I and I2V), Local danger / hazard warning (V2V), Post crash warning (V2V), Cooperative intersection collision warning (V2V and V2I). The vehicle fleets and annual kilometres driven were forecasted up to 2030. The new vehicle penetration rates as well as retrofit system penetrations were transferred to forecasted penetrations of whole vehicle fleet and kilometres travelled in EU25 in 2020 and 2030. The infrastructure equipment rates were forecasted for the three systems requiring infrastructure components. The effects of the systems were assessed with state of the art methodologies used in recent European projects. The results were validated in a specific workshop.</td>
</tr>
<tr>
<td>CO-GISTICS</td>
<td>2014-2016</td>
<td>Complete</td>
<td>CO-GISTICS is the first European project fully dedicated to the deployment of cooperative intelligent transport systems (C-ITS) applied to logistics. CO-GISTICS services will be deployed in 7 logistics hubs, Arad (Romania), Bordeaux (France), Bilbao (Spain), Frankfurt (Germany), Thessaloniki (Greece), Trieste (Italy) and Vigo (Spain). With 33 partners including public authorities, fleet operators, trucks, freight forwarders, terminal operators and logistics providers, the CO-GISTICS consortium will install the services on at least 325 vehicles (trucks and vans) and will run for 3 years (until January 2016).</td>
</tr>
<tr>
<td>COLOMBO</td>
<td>2012-2015</td>
<td>Complete</td>
<td>Cooperative Self-Organizing System for low Carbon Mobility at low Penetration Rates. In detail, two key objectives are considered. The first is the determination of the traffic state by collecting information obtained from V2X-heartbeat messages, as well as on-board and personal devices, such as PDAs which are fused for obtaining local and global network states. The second one is to use this information for making traffic lights adaptive to the current traffic state.</td>
</tr>
<tr>
<td>COMeSafety2</td>
<td>2011-2013</td>
<td>Complete</td>
<td>The overall goal of COMeSafety2 is to support the realisation and possible deployment of cooperative, communication based active safety systems. The project provides information to the European Commission about relevant technical and organisational matters. It is dedicated to foster wide agreement on technical issues on the one hand, but also wide agreements on deployment strategies on the other.</td>
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<tr>
<td>COMOSEF</td>
<td>2011-2015</td>
<td>Complete</td>
<td>Based on the work carried out in the previous Celtic projects (Carlink - Wireless Traffic Service Platform for Linking Cars, WiSafeCar – Wireless Safety Network between Cars) the CoMoSeF project aims to define advanced co-operative mobility use cases, based on user requirements and to produce targeted services for each pilot application to increase traffic safety, traffic fluency and to decrease the amount of accidents and incidents. The applications to be used both by commercial vehicles (taxis, trucks, buses) and private cars will be developed, implemented, tested and ultimately deployed in the various participating countries. The common CoMoSeF architecture and applications, which are based on the latest co-operative mobility standards, will be defined and specified so that they may be used as a starting point, when developing the pilots.</td>
</tr>
<tr>
<td>COMPASS4D</td>
<td>2013-2015</td>
<td>Complete</td>
<td>The European project Compass4D focuses on three services (The Red Light Violation Warning RLVW, The Road Hazard Warning RHW, The Energy Efficient Intersection EEI) which will increase drivers' safety and comfort by reducing the number and severity of road accidents as well as avoiding queues and traffic jams. Compass4D will also have a positive impact on the local environment by reducing vehicles' CO2 emissions and fuel consumption. Seven European cities: Bordeaux, Copenhagen, Helmond, Newcastle, Thessaloniki, Verona and Vigo.</td>
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<tr>
<td>CONVERGE</td>
<td>2012-2015</td>
<td>Complete</td>
<td>COmmunication Network VEhicle Road Global Extension. The stated goal of CONVERGE is the definition of an architecture and interfaces for an open, distributed, transregional/international connecting, provider-independent, scalable, flexible, secure and hybrid communicating Car2X Systems Network. For this purpose the basic network architecture (central, P2P, hierarchical) has to be defined. Furthermore, concepts must be developed, which comprises the IT security and privacy as well as data management. CONVERGE is important as DENM messages are communicated not only using ITS-G5 but over 3G and LTE. Materially, this means smartphones can receive 12V messages.</td>
</tr>
<tr>
<td>COOPERS</td>
<td>2006-2010</td>
<td>Complete</td>
<td>Project Mission: To define, develop and test new safety related services, equipment and applications using two way communications between road infrastructure and vehicles from a traffic management perspective. COOPERS aimed to build upon existing equipment and infrastructure as far as possible to incorporate bidirectional infrastructure-vehicle links as an open standardised wireless communication technology. The role of motorway-operators in offering and retrieving safety relevant and traffic management information for specific road segments on European motorways based on infrastructure and in-vehicle data was a subject to be investigated.</td>
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<tr>
<td>COSMO</td>
<td>2010-2013</td>
<td>Complete</td>
<td>COSMO aims to install and run practical demonstrations of a range of these new services in realistic conditions, in order to produce - quantified results of the impact of given cooperative systems on the environment with regards to fuel consumption and CO2 emissions - detailed specifications covering technical, legal and organisational issues involved in deployment of those systems, including indications on their procurement, installation, operation and maintenance Business Plans for the various systems are another crucial output of the project. These will be linked to a further important legacy, which is the set of pilot sites that will remain operational after COSMO has closed.</td>
</tr>
<tr>
<td>C-Roads Austria</td>
<td>2016-2020</td>
<td>On-going</td>
<td>The Austrian pilot contributes to interoperable European C-ITS solutions starting from the EU C-ITS Corridor. The implementation is linked to the C-ITS Strategy AUSTRIA of the Ministry for Transport, Innovation and Technology - bmvi, which defines the C-ITS deployment steps for the years till 2020 in an organisational framework, including the cooperation with public entities and industrial stakeholders. The Austrian C-Roads-Pilot builds on the core elements of the EU C-ITS Corridor project in Austria (ECo_AT) and extends them to a motorway based network of C-ITS stations in 2020, as defined in the Austrian C-ITS Strategy.</td>
</tr>
<tr>
<td>C-Roads Belgium/Flanders</td>
<td>2016-2020</td>
<td>On-going</td>
<td>The main objective of the C-Roads Flemish pilot is to operate and assess the deployment of a cloud based ‘virtual infrastructure’ for an effective deployment of C-ITS services connecting road users with the Traffic Management Centre (TMC) while allowing the TMC to directly interact with end users. The pilot also will bring an opportunity to upgrade Traffic Information Services and Traffic Management Services as offered today.</td>
</tr>
<tr>
<td>C-Roads Czech Republic</td>
<td>2016-2020</td>
<td>On-going</td>
<td>C-Roads Czech Republic aims to deploy cooperative systems (C-ITS) in compliance with relevant standards in order to achieve an interoperable system on European level providing harmonised services to its users (drivers, authorities, etc.), regardless of the technology used within the vehicles. The significant goal of C-Roas Czech Republic is to verify coexistence, reliability, security and functioning of the mutual linking between communication technologies ITS-G5 and LTE-V called as hybrid cooperative system, which mainly reduces deployment costs and increases reliability of the system. Considerable effort will be devoted to the security of the hybrid communication which is paramount of importance.</td>
</tr>
<tr>
<td>C-Roads France</td>
<td>2016-2020</td>
<td>On-going</td>
<td>C-Roads France is set up by 14 French beneficiaries covering the whole functional chain of C-ITS systems and services, including most partners of SCOOP@F but also cities, new road operators and academic partners. C-ROADS France builds mainly on SCOOP@F project to experiment and assess high-level C-ITS services.</td>
</tr>
<tr>
<td>C-Roads Germany</td>
<td>2016-2020</td>
<td>On-going</td>
<td>Germany as Member State will contribute to the C-Roads cooperation by the findings of the implementation and operation of seven different C-ITS services, which will be deployed in two different pilot sites and harmonised by the Federal Highway Research Institute (BAS).</td>
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<tr>
<td>C-Roads Netherlands</td>
<td>2016-2020</td>
<td>On-going</td>
<td>Based on the work on services for InterCor, the Netherlands will provide enhanced and extended test fields including strategic sections of the TEN-T Core Network, thus strengthening the efforts of the C-Roads community.</td>
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<tr>
<td>C-Roads Slovenia</td>
<td>2016-2020</td>
<td>On-going</td>
<td>The pilot in Slovenia will test a hybrid solution, in particular, C-ITS-G5 infrastructure and 3G/4G/LTE Cellular that will interact with Cloud Information Services to deliver C-ITS Day 1.0 services. “Infrastructure to vehicle” (I2V) as well as “Vehicle to infrastructure” (V2I) communication will be tested. In order to test the C-ITS Day 1.0 services with different solutions, the ITS infrastructure will be upgraded on the network as well as data integrated into the regional traffic management centre.</td>
</tr>
<tr>
<td>C-Roads UK</td>
<td>2016-2020</td>
<td>On-going</td>
<td>Based on the work on services from the InterCor pilot, services will be tested along strategic sections of the British part of the TEN-T Core Network. The British work on the pilot is concentrated on the fulfilment of the core Day-1 services, namely probe vehicle data, green light optimal speed advisory, in-vehicle signage and road works warning. The communication will be either G5 only, or hybrid (separate G5 and cellular). For freight services, important for InterCor, a Cellular Only solution will be established.</td>
</tr>
<tr>
<td>C-The Difference</td>
<td>2016-2018</td>
<td>On-going</td>
<td>C-TheDifference is a 2-year pilot project funded by DG MOVE with the aim to gain insight into the effects of urban C-ITS services. In Bordeaux, the focus is on the roll out of more services and use of 3G/4G, while in Helmond the focus is on the use of ITS G5 and expansion of the fleet of professional users. In this session we will also share the developments and lessons learned from preceding projects such as Freilot and Compass4D.</td>
</tr>
<tr>
<td>DIAMANT</td>
<td>2008-2013</td>
<td>Complete</td>
<td>DIAMANT stands for Dynamische Informationen und Anwendungen zur Mobilitätssicherung mit Adaptiven Netzwerken und Telematikanwendungen or Dynamic Information and Applications for assured Mobility with Adaptive Networks and Telematics infrastructure. DIAMANT is a regional project under the form of a Public-Private Partnership. The aim of the DIAMANT project is to create the prerequisites for a sustained increase in efficiency and safety in road traffic by means of vehicle-vehicle and vehicle-infrastructure communication (C2X-communication). Rapid deployment of applications to improve road safety and harmonise the traffic flow by means of a Public Private Partnership (PPP) that covers the complete range of expertise required. To prepare existing research results for regular operation. To implement the following applications: Information for drivers Warnings for drivers Virtual influence on traffic</td>
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<tr>
<td>DRIVE C2X</td>
<td>2011-2014</td>
<td>Complete</td>
<td>With 34 partners, 13 support partners and a 18.5 million Euro budget, DRIVE C2X lays the foundation for rolling out cooperative systems in Europe, leading to safer, more economical and more ecological driving. Funded with 12.4 million Euro by the European Commission, DRIVE C2X will carry out a comprehensive assessment of cooperative systems through Field Operational Tests</td>
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<td>Drive ME</td>
<td>2014-2018</td>
<td>On-going</td>
<td>TEST probes in real traffic. Testing of 100 highly automated Volvo cars in real traffic with real customers around 50 km of roads in Gothenburg during 2017-2018. The main objective of this trail is to examine the effect of the highly automated cars on the Swedish Transport Administration service qualities namely,: Energy efficiency, Safety, Traffic flow. Moreover, study the potential benefits when self-driving cars are introduced on a larger scale in road transportation system. The test probes (rebuilt vehicles) are to be considered as measuring equipment in a real traffic environment to collect data for analysis, modelling and quantification in order to among others developing a set of suitable effect catalogue for addressing different areas within traffic technique, when highly automated vehicles are introduced.</td>
</tr>
<tr>
<td>EasyWay</td>
<td>2007-2012</td>
<td>Complete</td>
<td>The EasyWay Projects phase I (2007-2009) and phase II (2010-2012) have been co-funded by the European Commission and are part of the EasyWay Global Programme 2007-2020. EasyWay I and II are Projects for deployment of Europe-wide ITS systems and services on TEN-T road network and its interfaces with urban areas and other modes of transport. The main objectives of EasyWay I and II were to improve safety, to reduce congestion and to reduce environmental impacts through the coordinated deployment of real-time information and traffic management services, supporting the creation of a seamless European transport system through coordinated ITS deployment. EasyWay incorporates eight Euro-Regions (CENTRICO, STREETWISE, ITHACA, SERTI, ARTS, CORVETTE, CONNECT, VIKING) facilitating the integration of all new Member States. It reinforces the co-operation between the existing participating countries by providing a new integrated framework with clear objectives and reporting methods. The eight Euro Regions will retain the management structure for EasyWay. More than 21 member states involved. C-ITS was dealt with the Cooperative Systems Task Force, producing as its most valuable results the road operators' priority services (7 services), stakeholder analysis, benefit-cost assessment of priority system deployment in six countries (AT, DE, FR, NL, SE, UK) as well as EU-27, and finally a vision and road map for C-ITS deployment from the road operator perspective.</td>
</tr>
<tr>
<td>eCall.at</td>
<td>2015-2017</td>
<td>Complete</td>
<td>eCall.at focusses on the implementation of eCall in Austria. The key element of the proposed Action is the piloting and subsequent implementation and certification phase of 9 Public Safety Answering Points (PSAPs), in line with the requirements defined by the EU regulations and specifications on eCall. Additionally, a set of training measures for PSAP operators will be defined and prepared to ensure the correct handling of eCalls. Dissemination activities will be defined and conducted to ensure close cooperation with rescue services as well as road operators and OEMs (Original Equipment Manufacturers) in Austria. eCall.at will also pilot cross-border cooperation to enable proper handling of eCalls in the border regions, via contacts and agreements with neighbouring Member States.</td>
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| ECo-AT      | 2013-2017   | Complete  | ECo-AT (European Corridor – Austrian Testbed for Cooperative Systems) is the Austrian project to create harmonised and standardised cooperative ITS applications jointly with partners in Germany and the Netherlands. The project is led by the Austrian motorway operator ASFiNAG and the consortium consists of Kapsch TrafficCom AG, Siemens AG Österreich, IPTE – Schalk & Schalk OG, SWARCO AG, High Tech Marketing, Volvo Technology AB, FTW, ITS Vienna Region, and BASt (Bundesanstalt für Straßenwesen).

The main objective of the project ECo-AT is to close the gap between research and development and the deployment of cooperative ITS services, namely by:
- definition of all elements necessary for "Day One" in cooperation with industry partners
- adaption of the industry partners ITS products and ASFiNAG procedures
- system testing within the framework of a "Living Lab"
- deployment of "Day One" services within the framework of an Austrian corridor as part of the C-ITS corridor Rotterdam-Frankfurt-Wien

Use cases and specifications will be reused in Holland and Germany by other members of the Amsterdam group, the Nordic Traffic Authorities and the upcoming NordicWay project.                                                                                                                                                                                                                                                                                                                                 |
<p>| eCO-FEV     | 2012-2015   | Complete  | This project will be carried out within the FP7 Work Programme 2011 COOPERATION of the European Commission addressing the objective GC-ICT-2011.6.8 ICT for fully electric vehicles. In particular, the project aims at fulfilling the specific targeted outcome f): Integration of the FEV in the cooperative transport infrastructure. It proposes will develop an integrated IT platform that enables the connection and information exchanges between multiple infrastructure systems that are relevant to the FEV such as road IT infrastructure, EV backend infrastructure and EV charging infrastructure. Over this platform, multiple advanced electric mobility services are able to be provided to FEV users to improve the energy management efficiency and usability of the FEV.                                                                                                                                                                                      |
| EcoGem      | 2010-2013   | Complete  | EcoGem will base its approach on rendering the FEV:(i) capable of reaching the desired destinations through the most energy efficient routes possible; (ii) fully aware of surrounding recharging points/stations while on the move. To achieve its goals, EcoGem will develop and employ novel techniques: (i) on-going learning-based traffic prediction; (ii) optimised route planning; (iii) interactive and inter-operative traffic, fleet and recharging management via V2V and V2I interfaces and communication. EcoGem's key-objective is to infuse intelligence and learning functionalities to on-board systems, enabling autonomous as well as interactive learning through V2X interfacing.                                                                                                                                                                                                 |</p>
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<td>EcoMove</td>
<td>2010-2014</td>
<td>Complete</td>
<td>eCoMove is a 3-year integrated project (April 2010 - January 2014), funded by the European Commission under the 7th Framework Programme of Research and Technological Development. This project has created an integrated solution for road transport energy efficiency to help drivers, freight and road operators: - Save unnecessary kilometres driven (optimised routing) - Save fuel (eco-driving support) - Manage traffic more efficiently (optimised network management) The project’s core concept is that there is a theoretical minimum energy consumption achievable with the “perfect eco-driver” travelling through the “perfectly eco-managed” road network.</td>
</tr>
<tr>
<td>eIMPACT</td>
<td>2006-2008</td>
<td>Complete</td>
<td>eIMPACT assesses the socio-economic effects of Intelligent Vehicle Safety Systems (IVSS), their impact on traffic safety and efficiency. It addresses policy options and the views of the different stakeholders involved: users, OEMs, insurance companies, and society. With determining these effects, eIMPACT also provides an indication of the prospects for introducing IVSS. eIMPACT is part of the EU's Sixth Framework Programme for Information Society Technologies and Media and will run for two and a half years until July 2008. eIMPACT is short for “Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems (IVSS) in Europe”; the consortium is led by TNO and comprises 13 partners that represent OEMs, research institutes and universities, encompassing many EU states.</td>
</tr>
<tr>
<td>EURIDICE</td>
<td>2009-2012</td>
<td>Complete</td>
<td>Supported by EUR 8.25 million in funding from the European Commission, the team behind the EURIDICE* project implemented their system in eight different pilot studies involving transport and logistics operators across Europe. EURIDICE aimed to use 'cooperative systems' - systems (or objects) that communicate with each other and their surroundings - to provide the right information in the right place at the right time at low cost, using modern communication networks.</td>
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### euroFOT

**Dates:** 2008-2011  
**Status:** Complete  
**Description:** 8 functionalities, 28 partners, 1000 vehicles... One Field Test. euroFOT has brought together a comprehensive array of organisations to test intelligent vehicle systems across Europe. Car manufacturers, suppliers, universities, research institutes and others stakeholders – in all 28 organisations are involved. The aim: to make road transport safer, more efficient and more pleasant! euroFOT establishes a comprehensive, technical, and socio/economic assessment programme for evaluating the impact of intelligent vehicle systems on safety, the environment, driver efficiency. The project assesses several technically mature systems using vehicles that include both passenger cars and trucks across Europe. A variety of intelligent vehicle systems (IVS) are being tested on a large scale in real driving conditions. About 1000 IVS-equipped vehicles will be driven over the course of one year, tested on roads across Europe. The objectives of the testing are to:  
- Assess various aspects of in-vehicle systems, such as their capabilities and performance, and the driver’s behaviour and interactions with those systems  
- Gain a better understanding of the short- and long-term socio-economic impact of such systems on safety, efficiency and driver comfort  
- Provide early publicity of the systems to the consumer and create wider acceptance of them

### FOT-Net Data

**Dates:** 2014-2016  
**Status:** Complete  
**Description:** FOT-Net Data, Field Operational Test Networking and Data Sharing Support, is a 3-year support action project to support the efficient sharing and re-use of available FOT (Field Operational Tests) datasets, develop and promote a framework for data sharing, build a detailed catalogue of available data and tools and operate an international networking platform for FOT activities. FOT-Net Data is a continuation of FOT-Net 1 and 2 and is funded under the 7th Framework Programme for Research and Technological Development.

### FOT-Net1

**Dates:** 2008-2010  
**Status:** Complete  
**Description:** See FOT-Net 2

### FOT-Net2

**Dates:** 2011-2013  
**Status:** Complete  
**Description:** The FOT-Net project has been in place for six years (2008-2013) as the networking platform for stakeholders involved or interested in Field Operational Tests (FOTs). The FOT-Net project aims to gather European and international stakeholders in a strategic networking platform to present results of Field Operational Tests (FOTs), identify and discuss common working items and promote a common approach for FOTs – the FESTA methodology. FOT-Net is a Specific Support Action funded by the European Commission DG Information Society and Media under the Seventh Framework Programme.
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<td>FOTsis</td>
<td>2011-2014</td>
<td>Complete</td>
<td>FOTsis (European Field Operational Test on Safe, Intelligent and Sustainable Road Operation) is a largescale field testing of the road infrastructure management systems needed for the operation of seven close-to-market cooperative I2V, V2I &amp; I2I technologies (the FOTsis Services), in order to assess in detail both 1) their effectiveness and 2) their potential for a full-scale deployment in European roads. Specifically, FOTsis will test the road infrastructure's capability to incorporate the latest cooperative systems technology at 9 Test-Sites in four European Test-Communities (Spain, Portugal, Germany and Greece), providing the following services: S1: Emergency Management, S2: Safety Incident Management, S3: Intelligent Congestion Control, S4: Dynamic Route Planning, S5: Special Vehicle Tracking, S6: Advanced Enforcement, S7: Infrastructure Safety Assessment</td>
</tr>
<tr>
<td>FREILOT</td>
<td>2009-2011</td>
<td>Complete</td>
<td>FREILOT - Urban Freight Energy Efficiency Pilot. FREILOT is an EC-funded Pilot that started in April 2009 for a duration of 2.5 years. The FREILOT services aim to increase energy efficiency in road goods transport in urban areas: Energy efficiency optimised intersection control Adaptive acceleration and speed limiters Enhanced &quot;green driving&quot; support Real-time loading/delivery space booking The general idea is that cities will implement priority for trucks at certain intersections (on certain roads and/or certain times of day) and provide this priority as incentive to the truck fleets which implement acceleration, speed limiters and provide eco-driving support to their drivers. In addition, cities will also provide possibilities to dynamically book and re-schedule delivery spaces. The services will be piloted in four European implementations: Lyon-France, Helmond-Netherlands, Krakow-Poland and Bilbao-Spain, to demonstrate up to 25% reduction of fuel consumption.</td>
</tr>
<tr>
<td>HIGHTS</td>
<td>2015-2018</td>
<td>On-going</td>
<td>HIGHTS is a Europe-base research project supported by European Union under the funding scheme &quot;Horizon 2020&quot;. Our theme is &quot;Smart, Green and Integrated Transport&quot; and our focus area is Cooperative ITS. The goal of the HIGHTS project is to achieve high precision positioning system with the accuracy of 25cm</td>
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<tr>
<td>iCOMPOSE</td>
<td>2013-2016</td>
<td>Complete</td>
<td>Integrated Control of Multiple-Motor and Multiple-Storage Fully Electric Vehicles. A key objective is: Integration of the unified controller with cloud-sourced information for the enhanced estimation and prediction of the vehicle states within a cooperative vehicle-road infrastructure,</td>
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<tr>
<td>ICSI</td>
<td>2012-2015</td>
<td>Complete</td>
<td>Intelligent cooperative sensing for improved traffic efficiency. The goal of the project is to define a new architecture to enable cooperative sensing in intelligent transportation systems and to develop a reference end-to-end implementation. The project results will enable advanced traffic and travel management strategies, based on reliable and real-time input data. The effectiveness of such new strategies, together with the proposed system, will be assessed in two field trials. [ITS]</td>
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<td>ICT4EVEU</td>
<td>2012-2014</td>
<td>Complete</td>
<td>The general objective of the proposal will be to deploy a set of ICT-based services for European Vehicles focused on the integration of innovative technologies; thus enhancing the user experience with an increasing geographical scope for the 3 kind of pilots: urban, regional and transnational. Specific objectives classified according to the technologies involved ICT solutions and smart systems integration: To make the driver aware of the remaining energy and of the resulting restrictions in terms of range and comfort. To recommend and guide the driver to the most suitable recharging station, according to the battery status and the grid availability. To conveniently book a charging point in advance at the suggested station simplifying the payment procedure with different charging point managers and receiving notifications when the EV is conveniently charged. To guarantee the access to reviews including information about the charging history, events, charging stations utilized.</td>
</tr>
<tr>
<td>INTERACTION</td>
<td>2008-2012</td>
<td>Complete</td>
<td>Understanding driver interactions with In-Vehicle Technologies is the main objective of INTERACTION project, which started in November 2008 for 42 months and gathers 10 European partners from 8 countries and 2 Australian institutes. This project is funded by the European Commission 7th Framework Programme (FP7).</td>
</tr>
<tr>
<td>Interactive</td>
<td>2010-2013</td>
<td>Complete</td>
<td>The interactIVe vision is accident-free traffic realised by affordable integrated safety systems available for all vehicle classes - systems that continuously assist the driver and intervene if necessary. interactIVe is motivated by the wish to reduce the number and the severity of accidents and injuries on the roads. The interactIVe project addresses the development and evaluation of next-generation safety systems for Intelligent Vehicles, based on active intervention. Safety technologies have shown outstanding capabilities for supporting the driver in hazardous situations. Despite their effectiveness, currently available systems are typically implemented as independent functions. This results in multiple expensive sensors and unnecessary redundancy, limiting their scope to premium-class vehicles.</td>
</tr>
<tr>
<td>ITSSv6</td>
<td>2011-2014</td>
<td>Complete</td>
<td>IPv6 ITS Station Stack for Cooperative Systems FOTs. ITSSv6 aims at developing a reference open-source IPv6 ITS Station stack available to European and national third parties (projects, industry and academia) using IPv6 for Internet-based communications in Field Operational Tests (FOTs) of Cooperative Systems. The IPv6 networking capabilities of the ITS Station under standardization at ISO TC204 WG16 (CALM) and ETSI TC ITS are extended with additional IPv6 features required for operational deployment of Cooperative Systems i.e. enhanced performance, embedded security, remote management of deployed systems and ease of configuration. The project takes as an input the FP6 CVIS core communication software and additional modules developed by FP7 GeoNet. It produces an enhanced IPv6 ITS Station stack adapted to operational use in large scale FOTs to the benefit of a variety of Cooperative Systems applications which require Internet communications (road safety, traffic efficiency and infotainment types.</td>
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The new software is validated on a basic open platform with recommended physical interfaces (802.11p and 3G).

### Ko-HAF

- **Dates:** 2015-2018
- **Status:** Complete
- **Description:** Ko-HAF – cooperative highly automated driving – aims for the next important step to automated driving possible, high automation. Key concept is on enabling high automation by means of a highly accurate digital map that is constantly updated by the fleet of automated vehicles. Another focus lies on Human-Machine-Interaction for highly automated systems.

### KONVOI

- **Dates:** 2005-2009
- **Status:** Complete
- **Description:** Electronically coupled trucks
  Within the project KONVOI an interdisciplinary research consortium developed and tested a driver assistance system, which enables the coupling of up to four trucks electronically. Thereby, longitudinal and lateral control of the following vehicles was taken over by the KONVOI-system. To realise the automated following of trucks, various systems will be combined (via sensor fusion) and a vehicle to vehicle communication will be used. Through the interplay of driver and assistance system, the KONVOI-system is supposed to contribute to the increase in traffic security, to decrease fuel consumption and CO2 emission and to lead to an improvement in traffic flow.

### LeCross

- **Dates:** 2013-2014
- **Status:** Complete
- **Description:** Funded by the European Space Agency
  - Road type: Road/Rail
  - Scale of deployment: Feasibility study

### MAVEN

- **Dates:** 2016-2019
- **Status:** On-going
- **Description:** MAVEN, a new European research project starting in September 2016, will investigate the role of traffic management in a future of increasingly automated vehicles. It expects to cover a wide range of subjects, including the role of road side equipment (e.g., traffic lights); interaction between the infrastructure and the fully automated vehicle in terms of eg, speed advisory, platooning or lane change advisory; the impact on vulnerable road users (pedestrians and cyclists), among others.

### Mobility2.0

- **Dates:** 2012-2015
- **Status:** Complete
- **Description:** Mobility2.0 will develop and test an in-vehicle commuting assistant for FEV mobility, resulting in more reliable and energy-efficient electro-mobility. The project will specify the scalable broadcasting of FEV recharging spot notification over 5.9 GHz networks and MBMS technology. The project will specify and contribute to standardisation the technology which enables plugged-in FEVs to act as 5.9 GHz road-side units, maintaining infrastructure connectivity via the V2G interface.
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<td>2012-2015</td>
<td>Complete</td>
<td>MOBINCITY aims at the optimization of FEV autonomy range and the increase in energy efficiency thanks to the development of a complete ICT-based integrated system able to interact between driver, vehicle and transport and energy infrastructures, taking advantage of the information provided from these sources in order to optimise both energy charging and discharging processes (trip planning and routing). Main specific objectives are: To develop a system to be installed within the vehicle able to receive information from the surrounding environment, which can have influence in the vehicle performance (traffic information, weather and road conditions and energy grid). To optimise the trip planning and routing of FEV using information from these external sources including alternatives from other transport modes adapted to user's needs. To define efficient and optimum charging strategies (including routing) adapted to user and FEV needs and grid conditions. To implement additional energy saving methods (as driving modes and In-Car Energy Management Services) within the FEV interaction with the driver.</td>
</tr>
<tr>
<td>MOLECULES</td>
<td>2012-2014</td>
<td>Complete</td>
<td>MOLECULES is a demonstration project with three large scale pilots in Barcelona, Berlin and Grand Paris aiming to use ICT services to help achieve a consistent, integrated uptake of Smart Connected Electromobility (SCE) in the overall framework of an integrated, environmentally friendly, sustainable mobility system. MOLECULES will include multiple types of e-vehicles, exploit synergies with ongoing initiatives, build on/licise with relevant stakeholders and emerging standards, as well as thoroughly assess the impacts of the three project pilots –including due consideration to the electricity mix used by the EVs. Furthermore, maximizing these impacts and facilitating deployment through scalability, dissemination actions, etc. will be a key priority.</td>
</tr>
<tr>
<td>NordicWay</td>
<td>2015-2017</td>
<td>Complete</td>
<td>NordicWay is a pre-deployment pilot of Cooperative ITS (C-ITS) cellular network based C-ITS services in four countries (Finland, Sweden, Norway and Denmark) with the purpose of demonstrating the technical performance, impacts, costs and acceptance of C-ITS. The primary goal is to prepare for a decision on large-scale deployment of C-ITS on the road networks of the Nordic countries. NordicWay will be followed by wide-scale deployment and potentially to be scaled up to Europe. NordicWay has the potential to improve safety, efficiency and comfort of mobility and connect road transport with other modes. NordicWay is the first large-scale pilot using cellular communication (3G and LTE/4G) for C-ITS. It offers continuous interoperable services to the users with roaming between different mobile networks and cross-border, offering C-ITS services across all participating countries. NordicWay puts emphasis on building a sustainable business model on the large investment of the public sector on the priority services of the ITS Directive. NordicWay is fully based on European standards and will act as the last mile between C-ITS research and development and wide-scale deployment. 50% of the funding is provided by the CEF.</td>
</tr>
<tr>
<td>OPTICITIES</td>
<td>2013-2016</td>
<td>Complete</td>
<td>OPTICITIES develops a collaborative approach between public and private stakeholders. In this vision European cities consolidate all mobility data available at local level and provide it to service operators through a standardised gateway.</td>
</tr>
<tr>
<td>Project</td>
<td>Dates</td>
<td>Status</td>
<td>Description</td>
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</tr>
<tr>
<td>OVERSEE</td>
<td>2010-2012</td>
<td>Complete</td>
<td>OVERSEE is a European research project funded within the 7th Framework Programme of the European Commission. The overall goal of OVERSEE is to contribute to the efficiency and safety of road transport by developing the OVERSEE platform, which will provide a secure, standardized and generic communication and application platform for vehicles. OVERSEE is the acronym for Open VEHiculaR SEcurE platform.</td>
</tr>
<tr>
<td>P4ITS</td>
<td>2013-2016</td>
<td>Complete</td>
<td>P4ITS is a thematic network gathering contracting authorities experienced or planning to shortly embark on deploying Cooperative ITS (C-ITS), and willing to improve the market roll-out of innovative transport systems and services through Public Procurement of Innovation (PPI). The network will enable exploring common issues and themes with counterparts from different countries, with a view to developing a more concerted approach for deploying C-ITS in Europe.</td>
</tr>
<tr>
<td>Platform Beter Benutten</td>
<td>2014-2018</td>
<td>Complete</td>
<td>Beter Benutten: Countering phantom traffic jams and shock wave traffic on the A58 motorway. Funding was received from national, regional and local authorities. Uses cooperative communication along a 17km stretch of motorway to stop ‘phantom traffic jams’, or shockwave damping. At first, this project will use cellular V2V communication to the driver’s phones but later in 2015 will move to Wi-Fi V2I communication for real-time advice. The information is displayed as a recommended speed to the driver. Beter Benutten may include the ‘SPITS-live’ project.</td>
</tr>
<tr>
<td>PRE-DRIVE C2X</td>
<td>2008-2010</td>
<td>Complete</td>
<td>PRE-DRIVE C2X’ main goal was twofold: The first goal was to specify and prototype a common European C2X communication system. The other goal was to develop the necessary tools for operating a field operational trial with cooperative systems on a European level and comprehensive assessment of the impacts.</td>
</tr>
<tr>
<td>PRESERVE</td>
<td>2011-2014</td>
<td>Complete</td>
<td>The mission of PRESERVE is, to design, implement, and test a secure and scalable V2X Security Subsystem for realistic deployment scenarios. Preserve Objectives: - Create an integrated V2X Security Architecture (VSA) and design, implement, and test a close-to-market implementation termed V2X Security Subsystem (VSS). - Prove that the performance and cost requirements for the VSS arising in current FOTs and future product deployments can be met by the VSS, especially by building a security ASIC for V2X. - Provide a ready-to-use VSS implementation and support to FOTs and interested parties so that a close-to-market security solution can be deployed as part of such activities. - Solve open deployment and technical issues hindering standardization and product pre-development.</td>
</tr>
<tr>
<td>Project</td>
<td>Dates</td>
<td>Status</td>
<td>Description</td>
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<td>----------</td>
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</tr>
</tbody>
</table>
| PReVENT | 2004-2008 | Complete | The Integrated Project PReVENT was a European automotive industry activity co-funded by the European Commission to contribute to road safety by developing and demonstrating preventive safety applications and technologies. The goal of Integrated Project PReVENT was to contribute to the:  
- road safety goal of 50% fewer accidents by 2010 - as specified in the key action 2.3.1.1 eSafety for Road and Air Transport from the European Union;  
- competitiveness of the European automotive industry;  
- European scientific knowledge community on road transport safety;  
- congregation and cooperation of European and national organisations and their road transport safety initiatives PReVENT envisions the early availability of advanced, next generation preventive and active  
- safety applications and enabling technologies and an accelerated deployment on European roads. |
| REGIOCROSS | 2008-2011 | Complete | Funded by the Czech Ministry of Transport.  
Road type: Railway crossing.  
Scale of deployment: Field testing on level-crossing in Brezhrad (nearby the town of Hradec Kralove) in the Czech Republic |
| ROADART  | 2015-2018 | Complete | ROADART is optimising the integration of Intelligent Transport Systems (ITS) communication units into trucks to boost their safety on the road.  
The project aims to demonstrate the road safety applications for truck-to-truck (T2T) and truck-to-infrastructure (T2I) systems under critical conditions in a real environment, such as tunnels and platooning of several trucks driving close behind each other. The demonstration use case will be a cooperative adaptive cruise control (C-ACC) allowing the trucks driving close behind each other. |
<table>
<thead>
<tr>
<th>Project</th>
<th>Dates</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAFESPOT</td>
<td>2006-2010</td>
<td>Complete</td>
<td>The SAFESPOT (2006 – 2010) project has demonstrated and tested the applications and use cases developed in different project activities through the scheduled tests that were realised at 6 different Test Sites. The Test Sites involving six European countries have used existing infrastructures equipped with new SAFESPOT systems and have tested interoperability among different countries. Four Test Sites were shared with the CVIS Integrated Project. Objective: The key to avoiding road accidents is to extend drivers' time/space horizon in their perception of safety-relevant information, and to improve the precision, reliability and quality of this information. The extent of 'perception' of autonomous vehicle-based systems cannot obviously go beyond the operative range of the sensors. Although effective real time awareness of the vehicle's &quot;surrounding environment&quot; can be achieved, this clearly has limits. SAFESPOT aims to: - Use the infrastructure and the vehicles as sources and destinations of safety-related information and develop an open, flexible and modular architecture and communication platform. - Develop the key enabling technologies: ad-hoc dynamic network, accurate relative localisation, dynamic local traffic maps. - Develop and test scenario-based applications to evaluate the impacts on road safety. - Define a sustainable deployment strategy for cooperative systems for road safety, evaluating also related liability, regulations and standardisation aspects.</td>
</tr>
<tr>
<td>Project</td>
<td>Dates</td>
<td>Status</td>
<td>Description</td>
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<tr>
<td>SCOOP@F</td>
<td>2014-2018</td>
<td>On-going</td>
<td>The SCOOP@F (Système Coopératif Pilote @ France) Project aims at deploying C-ITS from 2014 onwards in France. Its main objective is to improve the safety of road transport and of road operating staff during road works or maintenance. It consists of 5 specific sites with different types of roads: Ile-de-France, &quot;East Corridor&quot; between Paris and Strasbourg, Brittany, Bordeaux and Isère. SCOOP@F is composed of SCOOP@F Part 1 from 2014 to 2015 (ongoing) and SCOOP@F Part 2 from 2016 to 2018. It will equip 3000 vehicles and 2000 km of streets, intercity roads and highways. Part 1 of SCOOP@F deals with the study and pre-deployment phase. Five test sites will be created on intercity roads in Ile-de-France and Bretagne, the Paris-Strasbourg highway, Bordeaux and its bypass and county roads in the Isère. For each test site, roads and vehicles will communicate through wireless networks, i.e. using both wi-fi routers (along the road and embedded receptors in the vehicles) and public GSM networks. Part 1 of SCOOP@F will run from 2014 - 2015. SCOOP@F Part 2 will run from January 2016 to December 2018 and includes the validations of C-ITS services in open roads, cross border tests with other EU Member States and development of a hybrid communication solution (3G-4G/ITS G5). SCOOP@F Part 2 will cooperate with ongoing European pilot projects and the EU C-ITS platform. The project aims at reaching a critical mass in the number of tested vehicles, roads and services, in order to provide a representative evaluation of C-ITS. SCOOP@F Part 2 will cost EUR 20,036,598, of which EUR 10,018,299 will be provided by the EU CEF.</td>
</tr>
<tr>
<td>SCORE@F</td>
<td>2010-2013</td>
<td>Complete</td>
<td>SCORE @ F (Cooperative System Experimental Road @ France) is a collaborative C-ITS research project, which included FOTs. A French Field Operational Test for Road Cooperative Systems, in collaboration with DRIVE C2X and CO-DRIVE projects. The purpose of the project is to test a first set of thirteen use cases, in order to prepare a large-scale FOT before deployment. A hundred of naive drivers have been recruited and three test sites were opened in order to cover a diversity of driving situations. Most use cases were related to road-safety.</td>
</tr>
</tbody>
</table>
### Project: SIMPLI-CITY
- **Dates:** 2012-2015
- **Status:** Complete
- **Description:** SIMPLI-CITY will provide a holistic framework, which structures and bundles potential services that could deliver data from the various sources to road user information systems as well as allow road users to make use of the data and to integrate it into their driving experience. The main components of the SIMPLI-CITY system are:
  - **Mobility Service Framework:** A next-generation Europe-wide service platform allowing the creation of mobility-related services as well as the creation of corresponding Apps. This will enable third party providers to produce a wide range of interoperable, value-added services, and Apps for road users.
  - **Mobility-related Data as a Service:** A framework for the integration of various different data sources like sensors, cooperative systems, telematics, open data repositories, people-centric sensing, and media data streams, so that these data can be accessed and utilised in a unified way.
  - **Personal Mobility Assistant:** An end user assistant that allows road users to make easy use of the information provided by Apps and to interact with them based on a speech recognition approach.

### Project: simTD
- **Dates:** 2008-2013
- **Status:** Complete
- **Description:** The simTD research project is shaping tomorrow’s safe and intelligent mobility through researching and testing car-to-x communication and its applications. simTD will put the results of previous research projects into practice. For this purpose realistic traffic scenarios will be addressed in a large-scale test field infrastructure around the Hessian city of Frankfurt am Main. The project will also pave the way for the political, economic and technological framework to successfully set up car-to-car and car-to-infrastructure networking.

### Project: SISCOGA
- **Dates:** 2009-2011
- **Status:** Complete
- **Description:** A FOT for C2X applications will take place in Spain during 2010 and 2011 (SISCOGA, SIStemas COoperativos GaLicia). It will be based on an intelligent corridor, which is located in Galicia and will make use of the existing road network. CTAG (Galician Automotive Technology Centre) and DGT (Traffic Management in Spain), through the Northwest Management Traffic Centre, will use existing infrastructure (beacons, road posts...) of a road stretch to carry out the tests, equipping both in-roadside and more than 100 vehicles with the necessary hardware and software. The Traffic Management Centre of DGT in Spain controls the field equipment installed on the roads. This equipment communicates by a fibreoptic LAN network with SDH nodes finishing. Also, these stations communicate via 3G, which makes it possible to monitor their status continuously. Some of these stations are also connected to a weather station. The additional equipment included in this intelligent corridor comprehends more than 30 Road Side Units working at 5.9 GHz. Some of these Road Side units are placed just at the entrance of Vigo city, being capable to work with traffic lights information.

The vehicles are divided in the following groups: - 20 fully equipped (Class I) passenger vehicles, with 5.9 GHz on board Communication units, GPS, specific HMI and CAN logging. - 5 emergency vehicles also with Class I equipment - 2 buses and 2 trucks with Class I equipment - 80 Class II equipped vehicles, with GPS and UMTS.

Permanent corridor of more than 100 km to carry out field operational tests and pilots to test in real roads cooperative safety and efficiency applications. The cooperative corridor includes interurban (AP9, AP10, AP12), urban (AP9), mountainous (AP10), motorway (AP12) and local roads.
<table>
<thead>
<tr>
<th>Project</th>
<th>Dates</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPITS</td>
<td>2009-2011</td>
<td>Complete</td>
<td>SPITS is the Strategic Platform for Intelligent Traffic Systems: SPITS will create an open, scalable, real-time, distributed, sustainable, secure and affordable platform for cooperative ITS applications, evolving from existing infotainment systems.</td>
</tr>
<tr>
<td>TEAM</td>
<td>2012-2017</td>
<td>Complete</td>
<td>TEAM stands for Tomorrow’s Elastic Adaptive Mobility. It turns static into elastic mobility by joining drivers, travellers and infrastructure operators together into one collaborative network. Therefore TEAM explicitly takes into account the needs and constraints of all participants and the network itself.</td>
</tr>
<tr>
<td>TeleFOT</td>
<td>2008-2012</td>
<td>Complete</td>
<td>TeleFOT constitutes the largest pan-European Field Operational Test of functions provided by in-vehicle aftermarket and nomadic devices that has been conducted to date. The objectives of the TeleFOT project are to assess the impacts of functions provided by aftermarket and nomadic devices in vehicles and raise wide awareness of their traffic safety potential. These devices can provide different types of driver support functions and almost nothing is known about their safety and other impacts yet.</td>
</tr>
<tr>
<td>Testfeld Telematik</td>
<td>2011-2013</td>
<td>Complete</td>
<td>Testfield Telematik was an Austrian project to design, implement and validate a test field for demonstrating cooperative mobility services using data from the Vienna region. This ground-breaking international project was managed by ASFINAG and involved partners from all sectors of the ITS community.</td>
</tr>
<tr>
<td>Project</td>
<td>Dates</td>
<td>Status</td>
<td>Description</td>
</tr>
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<td>----------</td>
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</tr>
<tr>
<td>UK CITE</td>
<td>2016-2019</td>
<td>On-going</td>
<td>The project will enable automotive, infrastructure, and service provider companies to trial connected vehicle technology, infrastructure and services in real-life conditions. The connected environment will be on 40 miles of roads and will seek to understand how the technology can improve journeys, reduce traffic congestion and provide in-vehicle entertainment and safety services through better connectivity.</td>
</tr>
<tr>
<td>UR:BAN</td>
<td>2012-2016</td>
<td>Complete</td>
<td>Thirty partners including automobile and electronics manufacturers, suppliers, communication technology and software companies, as well as research institutes and cities, have joined in the cooperative project UR:BAN to develop advanced driver assistance and traffic management systems for cities. One of the main thematic target areas in UR:BAN are networked traffic systems which are focusing on economic and energy efficient driving: New information and communication technologies such as GPS/ Galileo, UMTS/ LTE and C2X enable novel methods for cooperative urban traffic management. By deployment of intelligent infrastructure and networking with intelligent vehicles, future advanced driver assistance systems will be able to implement instructions or advisories of strategic traffic management. In this way, traffic diversion and network optimization can take the energetic characteristics and other features of electric, hybrid, or conventionally powered vehicles into account. These key considerations will contribute to the goal of optimizing traffic and energy efficiency, achieving a high level of service (avoiding clogged roads), and reducing emissions in urban areas.</td>
</tr>
<tr>
<td>Vruits</td>
<td>2013-2016</td>
<td>On-going</td>
<td>VROOTS will assess societal impacts of selected ITS, provide evidence-based recommended practices on how VRU can be integrated in Intelligent Transport Systems and test these recommendations in field trials.</td>
</tr>
</tbody>
</table>
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Executive Summary

Study contract no. MOVE/B4/SER/2016-239/S12.762019

Written by: Kareen El Beyrouty

December 2018
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Executive Summary

Study contract no. MOVE/B4/SER/2016-239/S12.762019

Directorate-General for Mobility and Transport
Directorate B – Investment, Innovative & Sustainable Transport
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EXECUTIVE SUMMARY

This ‘Support study for Impact Assessment of Cooperative Intelligent Transport Systems’ reference MOVE/B4/2016-239, was conducted to assist the European Commission in developing a European framework to enhance the widespread deployment of C-ITS services. Cooperative Intelligent Transport Systems (C-ITS) enable vehicles to interact with each other and with the surrounding road infrastructure involving communication between vehicles (vehicle-to-vehicle, V2V), between vehicles and infrastructure (vehicle-to-infrastructure, V2I), infrastructure-to-infrastructure (I2I), and between vehicles and pedestrians or cyclists (vehicle-to-everything, V2X). The benefits of C-ITS span a range of areas, including improving road safety, reducing travel times, optimising transport efficiency, enhancing mobility, increasing service reliability, and reducing energy use and CO₂ and pollutant emissions.

This study chiefly focuses on mature C-ITS services that are expected to be deployed in the short and medium term. The C-ITS services covered in this study are grouped into different bundles:

- Bundle 1: Safety-based V2V services.
- Bundle 2: V2I services that deliver most benefit on motorways.
- Bundle 3: V2I services mostly applicable in urban areas.
- Bundle 4: Services intended to provide information regarding parking (and refuelling) to drivers.
- Bundle 5: Service intended to provide traffic and smart routing information to drivers.
- Bundle 7: V2X vulnerable road user protection service.

General objective

The general objective of the initiative is to establish a clear framework to increase deployment and uptake of C-ITS services across the EU, to significantly improve road safety and traffic efficiency.

Specific objectives

The specific objectives of this initiative are threefold:

- to provide an enabling environment to support pre-commercial deployment and enable the development of attractive business models;
- to reduce barriers and uncertainties to enable large-scale deployment of C-ITS; and
- to ensure interoperability and continuity of C-ITS services across the EU.

Policy options

This study assesses three policy options. The options were created from a long list of policy measures developed using stakeholder input and discussions with the European Commission. The policy measures follow six key themes, and each policy option includes at least one measure in each thematic area. The key themes are directly linked to the root causes of the problem definition developed for the study.

- ‘Privacy and protection of personal data’ measures respond to the challenge of deploying C-ITS in the context of existing legislation;
- ‘Security’ measures ensure the protection of personal data and the authentication of C-ITS messages, enabling provision of the service;
- ‘Interoperability’ measures enable EU-wide interoperability of C-ITS services, increasing the size of the market, the scope for network effects, and the reliable functioning of the services;
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

- ‘Compliance assessment’ measures incorporate procedures to ensure adherence to recommended or required specifications for C-ITS services and stations;
- ‘Continuity’ measures pave the way for continuous C-ITS services across borders; and
- ‘Enabling conditions’ measures encourage the market for C-ITS services to flourish.

The table below summarises the measures assessed under each policy option, as well as the measures under the study’s baseline.
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
<thead>
<tr>
<th>Privacy and protection of personal data, including access to data and data quality</th>
<th>Security</th>
<th>Interoperability</th>
<th>Compliance assessment</th>
<th>Continuity</th>
<th>Enabling conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline: Cross-cutting measures</strong></td>
<td></td>
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<tr>
<td>o EU policy: ITS Directive, C-ITS Strategy, Connected and automated mobility Strategy</td>
<td>o EU funding in the area e.g. under CEF (including funding / set-up of common EU security elements in 2018-2021)</td>
<td>o Industry deployment of C-ITS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Baseline: Thematic measures</strong></td>
<td>General Data Protection Regulation (GDPR) (includes all the requirements, such as mandatory Data protection impact assessment by data controller) ePrivacy Directive and its proposed update</td>
<td>Available non-binding guidance from the C-ITS platform; in particular the common security &amp; certificate policy Available non-binding guidance from C-ITS platform as to the roles/bodies needed (governance framework) EU C-ITS Security Credential Management System - Pilot 2018 - 2021 (CEF PSA)</td>
<td>List of Day 1 and 1.5 services agreed in the C-ITS platform &amp; 2016 EC Strategy Existing standards developed by e.g. ETSI/CEN Voluntary common service profiles available / being developed (e.g. the Car2Car and C-ROADS profiles)</td>
<td>ETSI Conformance test specifications Existing compliance assessment processes (e.g. for harmonized standards / CE marking) Station manufacturers voluntary apply ETSI conformance test specifications</td>
<td>Ongoing harmonisation &amp; deployment through C-Roads, CAR2CAR and ITS Committee</td>
</tr>
<tr>
<td>Policy option 1: Non-biding measures</td>
<td>Security</td>
<td>Interoperability</td>
<td>Compliance assessment</td>
<td>Continuity</td>
<td>Enabling conditions</td>
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<tr>
<td>EC adopts non-binding application guidelines for the GDPR in the context of C-ITS, including responsibilities and requirements.</td>
<td>EC adopts non-binding guidelines on European Union C-ITS Security Credential Management System (EU CCMS).</td>
<td>EC adopts non-binding guidelines on governance structure to support the provision of services as defined in the list of Day 1 services.</td>
<td>Reference to existing standards on interoperability and EU-wide service profiles in guidelines</td>
<td>EC adopts non-binding guidelines on the compliance assessment process for Day 1 C-ITS services.</td>
<td>Coordination and policy advice with stakeholders through stakeholder platform.</td>
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<tr>
<td></td>
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<td></td>
<td>Funding for development of services beyond the Day 1 list. MoUs with key stakeholders</td>
</tr>
<tr>
<td>Policy Option 2: Delegated Act</td>
<td>EC adopts binding application specifications for the GDPR in the context of C-ITS, including the responsibilities and requirements. Establishing purposes for lawfully processing personal data as traffic safety &amp; efficiency, with limitations (no commercial or law enforcement use).</td>
<td>Contents of CCMS is put into EU law, specifying C-ITS security requirements &amp; procedures. Possibility to update the CCMS, e.g. through a review clause.</td>
<td>Definition of needed roles in CCMS is put into EU law, plus a requirement to provide information to the Commission on the bodies/authorities in charge, if they have been set up.</td>
<td>Definition of Day 1 services list in specifications. C-ITS stations to be compatible with all Day 1 Services. Updatability of services and their definitions, e.g. through a review clause.</td>
<td>Mandate compliance with existing standards on inter-operability in specifications. Mandate compliance with EU-wide service profiles of Day 1 services in specifications. Issue a mandate to EU-level standardisation organisations for standardisation of services beyond the Day 1 list.</td>
</tr>
<tr>
<td>Policy Option 3: V2V mandate and legal bodies</td>
<td>PO2 combined with lawfully processing data based on legal obligation or public interest.</td>
<td>Same as PO2</td>
<td>PO2 + Assignment of roles to legal bodies.</td>
<td>Same as PO2</td>
<td>Same as PO2</td>
</tr>
</tbody>
</table>
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

Methods

This impact assessment support study employs a number of tools to estimate the potential impacts of C-ITS policy options:

- Literature and data review: to update the expected impacts of C-ITS services, C-ITS assumptions and other model inputs from the analysis carried out under a prior 2016 study (Ricardo-AEA, 2016).
- Stakeholder engagement: Feedback from the Public Consultation, case study interviews, a stakeholder workshop and other ad hoc interviews.
- Modelling: Pre-processing of assumption data and expected deployment for C-ITS under each scenario, followed by a series of modelling steps centred around the TRT ASTRA, TRT TRUST, and Ricardo CBA models to produce estimates of the indirect impacts of C-ITS.
- Qualitative Assessment: Multi-Criteria Analysis (MCA) has been used to narrow down the long list of policy measures, after which policy options were formulated from the final list. The direct impacts of C-ITS, based on the thematic areas in the problem definition, are assessed qualitatively based on the defined policy measures as well as stakeholder feedback. Some indirect impacts are also assessed qualitatively.

Direct Impacts

Direct impacts, assessed qualitatively for each root cause of the problem definition, are strongest under Policy Option 3, followed closely by Policy Option 2. Policy Option 1 impacts are small, but positive. The direct impacts of the three policy options considered, relative to the baseline, are summarised in the table below for each direct impact:

Key:

<table>
<thead>
<tr>
<th>Impact Type</th>
<th>Colour</th>
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</thead>
<tbody>
<tr>
<td>Significant positive impact</td>
<td>Green</td>
</tr>
<tr>
<td>Small positive impact</td>
<td>Light Green</td>
</tr>
<tr>
<td>Negligible/Neutral</td>
<td>Grey</td>
</tr>
<tr>
<td>Small negative impact</td>
<td>Yellow</td>
</tr>
<tr>
<td>Significant negative impact</td>
<td>Red</td>
</tr>
</tbody>
</table>
Table 0-1. Summary of direct impacts relative to the baseline for each Policy Option

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on privacy and protection of personal data</td>
<td>Provision of guidance removing some of the uncertainties, leading to small uptake and deployment increase. Identifying purposes for lawfully processing personal data for traffic safety and efficiency with some impact on removing uncertainties.</td>
<td>Provision of application specifications removing some of the uncertainties, leading to small uptake and deployment increase. Establishment of purposes for lawfully processing personal data for traffic safety and efficiency with significant impact on removing uncertainties.</td>
<td>Lawfully processing data, leading to greater uptake and deployment – helping to create attractive business models.</td>
</tr>
<tr>
<td>Security of C-ITS communications</td>
<td>The non-binding nature of the measures in the recommended CCMS policy limits their effect on security.</td>
<td>Strong measures to reduce deployment barriers related to security by putting CCMS policy into law. It is expected that this approach will have a significant impact on deployment, given the importance of security barriers.</td>
<td>The assignment of legal bodies is likely to ensure the necessary coordination and oversight of security issues, thus ensuring that barriers of C-ITS uptake due to security concerns are reduced to a minimum, leading to the greatest impact on uptake and deployment.</td>
</tr>
<tr>
<td>Impacts on interoperability</td>
<td>More clarity on definition of services and reference to existing standards, however the non-binding nature of the measures limits the impact on interoperability. A mandate for ESO to develop standardisation for services beyond the Day 1 list will ensure that standards are in place for future extensions of the scope beyond Day 1.</td>
<td>Significant positive impact expected on interoperability due to the binding nature of the measures.</td>
<td>Significant positive impact expected on interoperability due to the binding nature of the measures and mandatory deployment through the V2V mandate.</td>
</tr>
<tr>
<td>Impacts on compliance</td>
<td>Small, but limited impact expected due to guidelines providing more clarity on the compliance assessment process and roles and responsibilities.</td>
<td>Positive impacts achieved through specifications around the approvals process, minimum criteria as well as needed roles in relation to the approvals process. Some limitations of effectiveness (with varying uptake across country groups) due to non-binding requirement to set up bodies/authorities in charge.</td>
<td>Strong positive impact (higher than PO2) through assigning roles for compliance assessment to legal bodies as this ensures that compliance is assessed uniformly across Europe.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Policy Option 1</td>
<td>Policy Option 2</td>
<td>Policy Option 3</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Impacts on continuity</td>
<td>Some positive impact expected through stakeholder platform, but little direct</td>
<td>More positive impact on continuity compared to PO1 due to enhanced deployment</td>
<td>Significantly stronger measure than PO1 and PO2. Mandate on V2V services will be a very effective measure to ensure deployment of C-ITS services across Europe.</td>
</tr>
<tr>
<td></td>
<td>impact on continuity</td>
<td>coordination.</td>
<td></td>
</tr>
<tr>
<td>Impacts on enabling conditions</td>
<td>Positive impact on enabling conditions by providing funding for C-ITS development</td>
<td>Strong positive impact by providing funding for deployment projects linked to</td>
<td>Same as PO2</td>
</tr>
<tr>
<td></td>
<td>beyond Day 1 and bringing stakeholders together with MoUs.</td>
<td>data reporting and sharing. This knowledge exchange will have a significant</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>positive impact on learning and thus close gaps between Member States. EU</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>deployment coordination beyond the piloting phase will further support this.</td>
<td></td>
</tr>
</tbody>
</table>
Indirect Impacts

In addition to the direct impacts discussed above, indirect costs and benefits were assessed via the modelling framework. Costs estimated for C-ITS equipment, and the safety, economic, and environmental benefits modelled are shown in Error! Reference source not found.. The table also summarises total costs, total benefits, and net benefits for each policy option relative to the baseline. Net benefits, the key quantitative indicator for overall model results, are highest under Policy Option 3. They are more than 1.5 times the net benefits under Policy Option 2. Net benefits under Policy Option 2, while lower than those of Policy Option 3, are still nearly 4 times higher those under Policy Option 1.
### Table 0-2. Summary of modelled impacts for each Policy Option relative to the baseline

<table>
<thead>
<tr>
<th>Impact</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>New vehicles equipped (vehicles)</td>
<td>16.5 mn</td>
<td>79.0 mn</td>
<td>133.8 mn</td>
</tr>
<tr>
<td>New vehicles equipped in service by 2035</td>
<td>15.4 mn</td>
<td>73.5 mn</td>
<td>125.2 mn</td>
</tr>
<tr>
<td>Personal C-ITS devices equipped in service by 2035</td>
<td>19.9 mn</td>
<td>63.5 mn</td>
<td>16.7 mn</td>
</tr>
<tr>
<td><strong>Total vehicles equipped by 2035</strong></td>
<td><strong>35.3 mn</strong></td>
<td><strong>137.0 mn</strong></td>
<td><strong>141.9 mn</strong></td>
</tr>
<tr>
<td>Infrastructure upgraded (RSU)</td>
<td>81,000</td>
<td>142,000</td>
<td>181,000</td>
</tr>
<tr>
<td>New infrastructure deployed (RSU)</td>
<td>13,000</td>
<td>134,000</td>
<td>180,000</td>
</tr>
<tr>
<td>Central ITS sub-system deployed</td>
<td>370</td>
<td>439</td>
<td>440</td>
</tr>
<tr>
<td><strong>Total infrastructure equipped</strong></td>
<td><strong>94,000</strong></td>
<td><strong>276,000</strong></td>
<td><strong>322,000</strong></td>
</tr>
<tr>
<td>Total Cost (equipment costs)</td>
<td>n/a</td>
<td>C4.9 bn</td>
<td>C32.3 bn</td>
</tr>
<tr>
<td>Fatalities avoided</td>
<td>3,700</td>
<td>14,100</td>
<td>20,900</td>
</tr>
<tr>
<td>Serious Injuries avoided</td>
<td>46,000</td>
<td>152,000</td>
<td>209,000</td>
</tr>
<tr>
<td>Minor Injuries avoided</td>
<td>199,000</td>
<td>700,000</td>
<td>992,000</td>
</tr>
<tr>
<td><strong>Total accidents avoided</strong></td>
<td><strong>249,000</strong></td>
<td><strong>866,000</strong></td>
<td><strong>1,222,000</strong></td>
</tr>
<tr>
<td>Fuel consumption reduced (1000 litres)</td>
<td>4,460</td>
<td>20,084</td>
<td>32,111</td>
</tr>
<tr>
<td>Urban Travel time savings (million hours)</td>
<td>400</td>
<td>2,174</td>
<td>5,609</td>
</tr>
</tbody>
</table>

**Cost Impacts**

1. **New vehicles equipped (vehicles)**: €2.9 bn, €12.8 bn, €23.6 bn
2. **New vehicles equipped in service by 2035**: 73.5 mn, 125.2 mn
3. **Personal C-ITS devices equipped in service by 2035**: €3.8 bn, 16.7 mn
4. **Total vehicles equipped by 2035**: €3.8 bn, €16.6 bn, €29.5 bn
5. **Infrastructure upgraded (RSU)**: €0.3 bn, €0.5 bn, €0.4 bn
6. **New infrastructure deployed (RSU)**: €0.1 bn, €1.2 bn, €1.5 bn
7. **Central ITS sub-system deployed**: €0.7 bn, €0.9 bn, €0.9 bn
8. **Total infrastructure equipped**: €1.1 bn, €2.5 bn, €2.9 bn
9. **Total Cost (equipment costs)**: €4.9 bn, €19.1 bn, €32.3 bn

**Safety Benefits**

1. **Fatalities avoided**: €4.4 bn, €17.0 bn, €25.6 bn
2. **Serious Injuries avoided**: €8.0 bn, €26.9 bn, €37.6 bn
3. **Minor Injuries avoided**: €2.7 bn, €9.5 bn, €13.8 bn
4. **Total accidents avoided**: €15.0 bn, €53.4 bn, €76.9 bn

**Economic Benefits**

1. **Fuel consumption reduced (1000 litres)**: €2.5 bn, €11.2 bn, €18.2 bn
2. **Urban Travel time savings (million hours)**: €2.0 bn, €10.8 bn, €28.2 bn
## Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
<thead>
<tr>
<th>Impact</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cumulative</td>
<td>Discounted</td>
<td>Cumulative</td>
</tr>
<tr>
<td></td>
<td>impact relative</td>
<td>monetary</td>
<td>impact relative</td>
</tr>
<tr>
<td></td>
<td>to the baseline:</td>
<td>impact relative</td>
<td>to the baseline:</td>
</tr>
<tr>
<td></td>
<td>2020-2035</td>
<td>to the baseline:</td>
<td>2020-2035</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2020-2035</td>
<td></td>
</tr>
<tr>
<td>Environmental Benefits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Emission reduced (1000</td>
<td>12,000</td>
<td>€0.7 bn</td>
<td>54,000</td>
</tr>
<tr>
<td>tonnes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM reduced (tonnes)</td>
<td>44</td>
<td>€0.001 bn</td>
<td>-1,397</td>
</tr>
<tr>
<td>NOX reduced (tonnes)</td>
<td>8,234</td>
<td>€0.1 bn</td>
<td>29,878</td>
</tr>
<tr>
<td>VOC reduced (tonnes)</td>
<td>1,518</td>
<td>€0.002 bn</td>
<td>4,925</td>
</tr>
<tr>
<td>Total environmental benefit</td>
<td>n/a</td>
<td>€0.8 bn</td>
<td>n/a</td>
</tr>
<tr>
<td>Total Benefit</td>
<td>n/a</td>
<td>€20.3 bn</td>
<td>n/a</td>
</tr>
<tr>
<td>Net Benefit</td>
<td>n/a</td>
<td>€15.4 bn</td>
<td>n/a</td>
</tr>
</tbody>
</table>
In addition to the quantified impacts, several qualitative impacts were assessed. These are shown in Table 0-3.

**Table 0-3. Summary of indirect impacts assessed qualitatively or outside modelling framework, relative to the baseline**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Policy Option 1</th>
<th>Policy Option 2</th>
<th>Policy Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on vulnerable road users</td>
<td>No VRU-specific C-ITS services. Limited impacts achieved.</td>
<td>PO1 + coordination mechanisms and funding for the development of services beyond day-1 help implementation of VRU C-ITS services.</td>
<td>PO1 + coordination mechanisms and funding for the development of services beyond day-1 help implementation of VRU C-ITS services.</td>
</tr>
<tr>
<td>Impacts on administrative burden for MS and deployment projects</td>
<td>Compliance optional. If administrative burdens too high, Member States and projects would choose not to comply and avoid incurring high costs.</td>
<td>Key compliance costs are adherence to the Certificate and Security Policy and compliance assessment. Costs likely to be very low relative to the equipment costs for infrastructure.</td>
<td>No excess costs beyond those incurred in PO2.</td>
</tr>
<tr>
<td>Public/Private sector split in PV 2020-2035 equipment costs</td>
<td>Most expenditure by private sector (76.9% spend by private sector)</td>
<td>Most expenditure by private sector (86.8% spend by private sector)</td>
<td>Most expenditure by private sector (91.2% spend by private sector)</td>
</tr>
<tr>
<td>Employment impacts by 2035</td>
<td>Increase in EU28 employment relative to baseline (+0.003%)</td>
<td>Increase in EU28 employment relative to baseline (+0.011%)</td>
<td>Increase in EU28 employment relative to baseline (+0.013%)</td>
</tr>
<tr>
<td>R&amp;I impacts by 2035</td>
<td>Limited impact</td>
<td>Increase in R&amp;I activity due to greater policy &amp; regulatory certainty</td>
<td>Increase in R&amp;I activity due to greater policy &amp; regulatory certainty</td>
</tr>
<tr>
<td>Impacts on SMEs</td>
<td>Limited impact</td>
<td>Positive impacts due to greater policy &amp; regulatory certainty</td>
<td>Greatest impact due to policy &amp; regulatory certainty as well as enhanced deployment</td>
</tr>
</tbody>
</table>

**Comparison of Options**

- **Preferred Option:** The conclusion of this study is that Policy Option 2 is the preferred option, on the basis of superior performance on efficiency, as well as proportionality and subsidiarity. While Policy Option 3 scores best on effectiveness and coherence, the selection of Policy Option 2 does not preclude a future move to Policy Option 3 once the legal and policy avenues are better understood (and the considerations under proportionality and subsidiarity can be updated) and future performance under PO2 is assessed.

- **Effectiveness:** Policy Option 3 is the strongest across nearly all indicators against the three specific objectives defined in our problem tree and the indirect objectives regarding deployment and other indirect benefits.

- **Efficiency:** Policy Option 2 is the most efficient choice. There is a significant leap in the proportion of net benefits between Policy Option 1 and 2 (a 260 percent increase), while there is a lower increase in net benefits between Policy Option 2 and 3 (a 62 percent increase).
• **Coherence**: Policy Option 2 offers stronger performance than Policy Option 1 on coherence. Policy Option 3 performs slightly better than Policy Option 2 with regard to coherence. For this reason, Policy Option 3 is the best choice given the information available.

• **Proportionality and subsidiarity**: Both Policy Option 1 and 2 are proportional – allowing Member States to self-determine the level of deployment they prefer. The enhanced benefits under Policy Option 2 are proportional to the level of control delegated to the EU from Member States. Policy Option 3 imposes a direct obligation on vehicle OEMs, which has costs (both material and political). Given that significant benefits can be achieved already under Policy Option 2 without imposing this obligation, Policy Option 2 is considered more proportional than Policy Option 3.

**Sensitivity Analysis**

The study assessed three sensitivities on all policy options to understand separately the impacts of a 50% increase in equipment costs, a 10% decrease in projected deployment levels, and a 10% decrease in the expected effectiveness of C-ITS services. Overall, cumulative discounted net benefits between 2020 and 2035 remain positive for all policy options under all sensitivities.

Table 0-4 below summarises the results of the equipment cost sensitivity.

**Table 0-4. NPV benefits under policy options when equipment costs rise by 50%**

<table>
<thead>
<tr>
<th></th>
<th>PO1 2020-2030</th>
<th>PO1 2020-2035</th>
<th>PO2 2020-2030</th>
<th>PO2 2020-2035</th>
<th>PO3 2020-2030</th>
<th>PO3 2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV benefits</td>
<td>€5.0 bn</td>
<td>€15.4 bn</td>
<td>€20.4 bn</td>
<td>€59.8 bn</td>
<td>€36.8 bn</td>
<td>€96.5 bn</td>
</tr>
<tr>
<td>NPV benefits after 50% equipment cost increase</td>
<td>€4.0 bn</td>
<td>€13.5 bn</td>
<td>€15.6 bn</td>
<td>€51.5 bn</td>
<td>€27.2 bn</td>
<td>€81.8 bn</td>
</tr>
</tbody>
</table>

The results of the impact of 10% less deployment (deployment sensitivity) and of 10% lower effectiveness of C-ITS services (impact sensitivity) showed a more than proportionate decrease in expected benefits, but still yielded significantly positive net benefits:

- Under Policy Option 1, discounted net cumulative benefits between 2020 and 2035 fall from €15.4 billion to €11.2 billion and €12.6 billion under the deployment and impact sensitivities, respectively.
- For Policy Option 2, discounted net cumulative benefits decrease from €59.8 billion to €43.4 billion and €48.9 billion under the deployment and impact sensitivities.
- Under Policy Option 3, net benefits fall from €96.5 billion to €85.5 billion and €80.7 billion under the deployment and impact sensitivities.
SYNTHÈSE
Cette étude de soutien pour l'évaluation de l'impact des systèmes de transport coopératifs intelligents, référence MOVE / B4 / 2016-239, a été menée pour aider la Commission européenne à développer un cadre européen pour renforcer le déploiement généralisé des services C-ITS. Les systèmes de transport intelligents coopératifs (C-ITS) permettent aux véhicules d'interagir et d'interagir avec l'infrastructure routière environnante; des communications entre véhicules (véhicule à véhicule, V2V), entre véhicules et infrastructure (véhicule à infrastructure, V2I), infrastructure à infrastructure (I2I), et entre véhicules et piétons ou cyclistes (véhicule à tout, V2X). Les avantages des C-ITS couvrent de nombreux domaines, notamment l'amélioration de la sécurité routière, la réduction des temps de parcours, l'optimisation de l'efficacité des transports, la mobilité, la fiabilité des services et la réduction de consommation d'énergie et des émissions de CO₂ et de polluants.

Cette étude se concentre principalement sur les services C-ITS matures qui devraient être déployés à court et à moyen terme. Les services C-ITS couverts dans cette étude sont regroupés en différents groupes:

- Bundle 1: Services V2V basés sur la sécurité.
- Bundle 2: Les services V2I qui offrent le plus d'avantages sur les autoroutes.
- Bundle 3: Services V2I principalement applicables dans les zones urbaines.
- Bundle 4: Services destinés à fournir des informations concernant le stationnement (et le ravitaillement) aux conducteurs.
- Bundle 5: Service destiné à fournir des informations sur le trafic et le routage intelligent aux conducteurs.
- Bundle 7: V2X service de protection des utilisateurs vulnérables.

Objectif général
L'objectif général de l'initiative est d'établir un cadre clair pour accroître le déploiement et l'utilisation des services C-ITS dans l'UE, afin d'améliorer considérablement la sécurité et l'efficacité de la circulation routière.

Objectifs spécifiques
Les objectifs spécifiques de cette initiative sont triples:

- Créer un environnement propice au déploiement pré-commercial et permettre le développement de modèles d’affaires attractifs;
- Réduire les obstacles et les incertitudes pour permettre un déploiement à grande échelle des C-ITS; et
- Assurer l'interopérabilité et la continuité des services C-ITS dans l'UE.

Options politiques
Cette étude évalue trois options politiques. Les options ont été créées à partir d'une longue liste de mesures élaborées à partir des contributions et des discussions des parties prenantes avec la Commission européenne. Les mesures politiques suivent six thèmes principaux et chaque option politique comprend au moins une mesure dans chaque domaine thématique. Les thèmes clés sont directement liés aux causes de la définition du problème développée pour l'étude.

- Les mesures «Protection de la vie privée et protection des données à caractère personnel» répondent au défì du déploiement des C-ITS dans le contexte de la législation existante;
- Les mesures de «Sécurité» garantissent la protection des données personnelles et l'authentification des messages C-ITS, permettant la fourniture du service;
Les mesures «d'Interopérabilité» permettent une interopérabilité à l'échelle de l'UE des services C-ITS, en augmentant la taille du marché, la portée des effets de réseau et le fonctionnement fiable des services;

Les mesures «d'Évaluation de la conformité» intègrent des procédures garantissant le respect des spécifications recommandées ou requises pour les services et les stations C-ITS;

Les mesures de «Continuité» ouvrent la voie à la continuité des services C-ITS au-delà des frontières; et

Les mesures de «Création de conditions favorables» encouragent le développement du marché des services C-ITS.

Le tableau ci-dessous résume les mesures évaluées au titre de chaque option politique, ainsi que les mesures relevant de la base de référence de l'étude.
### Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
<thead>
<tr>
<th>Protection de la vie privée et protection des données à caractère personnel</th>
<th>Sécurité</th>
<th>Interopérabilité</th>
<th>Évaluation de la conformité</th>
<th>Continuité</th>
<th>Création de conditions favorables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exigences et procédures</strong></td>
<td><strong>Responsabilités / Organismes</strong></td>
<td><strong>Services</strong></td>
<td><strong>Spécifications de communication</strong></td>
<td><strong>Exigences et procédures</strong></td>
<td><strong>Responsabilités / Organismes</strong></td>
</tr>
</tbody>
</table>

#### Base de référence : Mesures transversales

- Projets de déploiement régionaux et nationaux, par exemple C-Roads
- Financement de l’UE dans ce domaine, par exemple dans le cadre du CEF (y compris le financement / la mise en place d’éléments de sécurité communs de l’UE en 2018-2021)
- Déploiement industriel de C-ITS

#### Base de référence : Mesures thématiques

<table>
<thead>
<tr>
<th>Règlement général sur la protection des données (GDPR) Directive ePrivacy et sa mise à jour proposée</th>
<th>Orientation non contraignant disponible de la plate-forme C-ITS; en particulier la politique commune de sécurité et de certificat</th>
<th>Liste des services des jours 1 et 1,5 convenus dans la plateforme C-ITS et la stratégie de la CE pour 2016</th>
<th>Spécifications du test de conformité ETSI</th>
<th>MoU C-Roads et C2C-CC existants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation non contraignantes disponibles de la plate-forme C-ITS quant aux rôles / organes nécessaires (cadre de gouvernance)</td>
<td>Profils de services communs volontaires disponibles / en cours de développement (par exemple les profils Car2Car et C-ROADS)</td>
<td>Les fabricants de stations appliquent volontairement les spécifications de test de conformité ETSI</td>
<td>Harmonisation et déploiement continu via C-Roads, CAR2CAR et le comité ITS</td>
<td>MoU C-Roads et C2C-CC existants</td>
</tr>
<tr>
<td>Protection de la vie privée et protection des données à caractère personnel</td>
<td>Sécurité</td>
<td>Interopérabilité</td>
<td>Évaluation de la conformité</td>
<td>Continuité</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Exigences et procédures</td>
<td>Responsabilités / Organismes</td>
<td>Services</td>
<td>Spécifications de communication</td>
<td>Exigences et procédures</td>
</tr>
<tr>
<td>Option politique 1: Mesures non contraignantes</td>
<td>EC adopte des lignes directrices d’application non contraignantes pour le GDPR dans le contexte des C-ITS, y compris les responsabilités et les exigences.</td>
<td>EC adopte des lignes directrices non contraignantes, notamment des exigences détaillées sur le contenu des documents de certificat et de politique de sécurité C-ITS européens communs (EU CCMS).</td>
<td>EC adopte des lignes directrices non contraignantes sur la structure / les organes de gouvernance nécessaires à la sécurité, des recommandations pour attribuer des rôles aux organismes.</td>
<td>La CE adopte des lignes directrices non contraignantes pour soutenir la fourniture de services telle que définie dans la liste des services Day 1.</td>
</tr>
<tr>
<td>Protection de la vie privée et protection des données à caractère personnel</td>
<td>Sécurité</td>
<td>Interopérabilité</td>
<td>Évaluation de la conformité</td>
<td>Continuité</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Exigences et procédures</td>
<td>Responsabilités / Organisme(s)</td>
<td>Services</td>
<td>Spécifications de communicatio</td>
<td>Exigences et procédures</td>
</tr>
<tr>
<td><strong>Option politique 2: Acte délégué</strong></td>
<td>EC adopte des spécifications d'application contraignantes pour le GDPR dans le contexte des C-ITS, y compris les responsabilités et les exigences. Établir des objectifs pour le traitement légal des données personnelles en tant que sécurité et efficacité du trafic, avec des limitations (pas d'utilisation commerciale ou d'application de la loi).</td>
<td>Le contenu du CCMS est inscrit dans la législation de l'UE, spécifiant les exigences et procédures de sécurité C-ITS. Possibilité de mettre à jour le CCMS, par exemple au moyen d'une clause de révision.</td>
<td>Définition de la liste des services Day 1 dans les spécifications. Les stations C-ITS doivent être compatibles avec tous les services Day 1. Mise à jour des services et de leurs définitions, par exemple au moyen d'une clause de révision.</td>
<td>Mandater la conformité aux normes d'interopérabilité existantes dans les spécifications. Mandater la conformité avec les profils de services à l'échelle de l'UE des services Day 1 dans les spécifications. Délivrer un mandat aux organisations de normalisation au niveau de l'UE pour la normalisation des services au-delà de la liste Day 1.</td>
</tr>
</tbody>
</table>
### Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
<thead>
<tr>
<th>Protection de la vie privée et protection des données à caractère personnel</th>
<th>Sécurité</th>
<th>Interopérabilité</th>
<th>Évaluation de la conformité</th>
<th>Continuité</th>
<th>Création de conditions favorables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exigences et procédures</td>
<td>Responsabilités / Organismes</td>
<td>Services</td>
<td>Spécifications de communicatiom</td>
<td>Exigences et procédures</td>
<td>Responsabilités / Organismes</td>
</tr>
<tr>
<td><strong>Option politique 3: Mandat et organes juridiques de V2V</strong></td>
<td>PO2 combiné avec le traitement légal des données basées sur une obligation légale ou d'intérêt public.</td>
<td>Identique à PO2</td>
<td>Identique à PO2</td>
<td>Identique à PO2</td>
<td>PO2 + Attribution des rôles à des organes juridiques.</td>
</tr>
<tr>
<td>PO2 combiné avec le traitement légal des données basées sur une obligation légale ou d'intérêt public.</td>
<td>PO2 + Attribution des rôles à des organes juridiques.</td>
<td>Identique à PO2</td>
<td>PO2 + Attribution des rôles à des organes juridiques.</td>
<td>PO2 + Déploiement obligatoire de la communication V2V.</td>
<td>Identique à PO2</td>
</tr>
</tbody>
</table>
Méthodes

Cette étude d’appui à l’évaluation d’impact utilise un certain nombre d’outils pour estimer les impacts potentiels des options de politique C-ITS :

- Engagement des parties prenantes: rétroaction de la consultation publique, entrevues d’études de cas, atelier avec les parties prenantes et autres entretiens.
- Modélisation: Pré-traitement des données d’hypothèses et déploiement prévu des C-ITS dans chaque scénario, suivi d’une série d’étapes de modélisation centrées sur les modèles TRT ASTRA, TRT TRUST et Ricardo CBA pour produire des estimations des impacts indirects de C-ITS.
- Évaluation qualitative: L’analyse multicroîtres (MCA) a été utilisée pour affiner la longue liste de mesures, après quoi les options stratégiques ont été formulées à partir de la liste finale. Les impacts directs des C-ITS, basés sur les domaines thématiques de la définition du problème, sont évalués qualitativement sur la base des mesures politiques définies et des commentaires des parties prenantes. Certains impacts indirects sont également évalués qualitativement.

Impacts directs

Les impacts directs, évalués qualitativement pour chaque cause fondamentale de la définition du problème, sont les plus forts dans l’option 3, suivie de près par l’option 2. Les impacts de l’option 1 sont faibles, mais positifs. Les impacts directs des trois options envisagées par rapport à la base de référence sont résumés dans le tableau ci-dessous pour chaque impact direct:

Clé:

<table>
<thead>
<tr>
<th>Impact positif significatif</th>
<th>Petit impact positif</th>
<th>Négligeable / Neutre</th>
<th>Petit impact négatif</th>
<th>Impact négatif significatif</th>
</tr>
</thead>
</table>
### Tableau 0-1. Résumé des impacts directs par rapport à la référence pour chaque option de politique

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Option politique 1</th>
<th>Option politique 2</th>
<th>Option politique 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impacts sur la vie privée et la protection des données personnelles</strong></td>
<td>Fourniture de lignes directrices supprimant certaines des incertitudes, conduisant à une faible adoption et augmentation du déploiement. Identifier les finalités du traitement légal des données à caractère personnel pour la sécurité du trafic et l’efficacité avec certaines impact sur la suppression des incertitudes.</td>
<td>Fourniture de spécifications d’application supprimant certaines des incertitudes, conduisant à une faible adoption et à une augmentation du déploiement. Établissement d’objectifs pour le traitement licite de données à caractère personnel pour la sécurité et l’efficacité du trafic, avec un impact significatif sur la suppression des incertitudes.</td>
<td>Traitement légal des données, permettant une utilisation et un déploiement accrus, contribuant ainsi à créer des modèles commerciaux attractifs.</td>
</tr>
<tr>
<td>** Sécurité des communications C-ITS**</td>
<td>Le caractère non contraignant des mesures du CCMS recommandée limite leur effet sur la sécurité.</td>
<td>Des mesures énergiques pour réduire les obstacles au déploiement liés à la sécurité en intégrant le CCMS dans la loi. Cette approche devrait avoir un impact significatif sur le déploiement, compte tenu de l’importance des barrières de sécurité.</td>
<td>L’attribution des organes juridiques assurera probablement la coordination et la surveillance nécessaires des problèmes de sécurité, réduisant ainsi au minimum les obstacles à l’adoption des C-ITS en raison de problèmes de sécurité, ce qui aura un impact majeur sur leur adoption et leur déploiement.</td>
</tr>
<tr>
<td><strong>Impacts sur l’interopérabilité</strong></td>
<td>Plus de clarté sur la définition des services et la référence aux normes existantes, mais Le caractère non contraignant des mesures limite l’impact sur l’interopérabilité. Un mandat de l’ESO pour développer la normalisation des services au-delà de la liste Day 1 garantira la mise en place de normes pour les futures extensions du champ d’application au-delà des services Day 1.</td>
<td>Impact positif significatif attendu sur l’interopérabilité en raison du caractère contraignant des mesures.</td>
<td>Impact positif significatif attendu sur l’interopérabilité en raison du caractère contraignant des mesures et du déploiement obligatoire dans le cadre du mandat V2V.</td>
</tr>
<tr>
<td><strong>Impacts sur la conformité</strong></td>
<td>Impact limité, attendu en raison des directives fournissant plus de clarté sur le processus d’évaluation de la conformité et les rôles et responsabilités.</td>
<td>Impacts positifs obtenus grâce aux spécifications relatives au processus d’approbation, aux critères minimaux et aux rôles nécessaires en rapport avec le processus d’approbation. Certaines limitations de l’efficacité (avec une utilisation variable selon les groupes de</td>
<td>Impact positif fort (supérieur à PO2) grâce à l’attribution de rôles à l’évaluation de la conformité aux organes juridiques, car cela garantit que la conformité est évaluée de...</td>
</tr>
<tr>
<td>Indicator</td>
<td>Option politique 1</td>
<td>Option politique 2</td>
<td>Option politique 3</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Impacts sur la continuité</td>
<td>Un impact positif attendu par le biais de la plate-forme des parties prenantes, mais peu d’impact direct sur la continuité.</td>
<td>Un impact plus positif sur la continuité par rapport au PO1 grâce à une meilleure coordination du déploiement.</td>
<td>Mesure significativement plus forte que PO1 et PO2. Le mandat sur les services V2V constituera une mesure très efficace pour assurer le déploiement des services C-ITS en Europe.</td>
</tr>
<tr>
<td>Impacts sur les conditions favorables</td>
<td>Impact positif sur les conditions favorables en fournissant un financement pour le développement des C-ITS au-delà du Day 1 et en réunissant les parties prenantes avec les protocoles d’accord.</td>
<td>Fort impact positif en fournissant un financement pour des projets de déploiement liés à la communication et au partage de données. Cet échange de connaissances aura un impact positif significatif sur l’apprentissage et réduira ainsi les écarts entre les États membres. La coordination du déploiement de l’UE au-delà de la phase de pilotage le soutiendra davantage.</td>
<td>Identique à PO2</td>
</tr>
</tbody>
</table>

pays) en raison de l’obligation non contraignante de créer des organes / autorités responsables. manière uniforme dans toute l’Europe.
Impacts indirects

En outre des impacts directs évoqués ci-dessus, les coûts et bénéfices indirects ont été évalués via un cadre de modélisation. Les coûts estimés pour l'équipement C-ITS et la sécurité, les avantages économiques et environnementaux modélisés sont présentés dans le tableau 0 - 2. Le tableau résume également les coûts totaux, les bénéfices totaux et les bénéfices nets pour chaque option de politique par rapport à la base de référence. Les bénéfices nets, l'indicateur quantitatif clé des résultats globaux du modèle, sont les plus élevés dans l'option 3. Ils représentent plus de 1,5 fois les bénéfices nets de l'option 2. Les bénéfices nets de l'option 2, bien que inférieurs à ceux de l'option 3, sont encore près de 4 fois supérieurs à ceux de l'option 1.
Tableau 0-2. Résumé des impacts modélisés pour chaque option de politique par rapport à la base de référence

<table>
<thead>
<tr>
<th>Impact</th>
<th>Option politique 1</th>
<th>Option politique 2</th>
<th>Option politique 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nouveaux véhicules équipés (véhicules)</strong></td>
<td>16,5 mn</td>
<td>79,0 mn</td>
<td>133,8 mn</td>
</tr>
<tr>
<td><strong>Nouveaux véhicules équipés en service par 2035</strong></td>
<td>15,4 mn</td>
<td>73,5 mn</td>
<td>125,2 mn</td>
</tr>
<tr>
<td><strong>Appareils personnels ITS équipés par 2035</strong></td>
<td>19,9 mn</td>
<td>63,5 mn</td>
<td>16,7 mn</td>
</tr>
<tr>
<td><strong>Total des véhicules équipés par 2035</strong></td>
<td>35,3 mn</td>
<td>3,8 md €</td>
<td>137,0 mn</td>
</tr>
<tr>
<td><strong>Infrastructure modernisée (RSU)</strong></td>
<td>81,000</td>
<td>142,000</td>
<td>142,000</td>
</tr>
<tr>
<td><strong>Nouvelle infrastructure déployée (RSU)</strong></td>
<td>13,000</td>
<td>134,000</td>
<td>181,000</td>
</tr>
<tr>
<td><strong>Sous-système ITS central déployé</strong></td>
<td>370</td>
<td>439</td>
<td>440</td>
</tr>
<tr>
<td><strong>Infrastructure totale équipée</strong></td>
<td>94,000</td>
<td>276,000</td>
<td>322,000</td>
</tr>
<tr>
<td><strong>Coût total (coûts d'équipement)</strong></td>
<td>n/a</td>
<td>4,9 md €</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Bénéfices de sécurité</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatalités évitées</td>
<td>3,700</td>
<td>14,100</td>
<td>17,0 md €</td>
</tr>
<tr>
<td>Blessures graves évitées</td>
<td>46,000</td>
<td>152,000</td>
<td>26,9 md €</td>
</tr>
<tr>
<td>Blessures mineures évitées</td>
<td>199,000</td>
<td>700,000</td>
<td>9,5 md €</td>
</tr>
<tr>
<td><strong>Total des accidents évités</strong></td>
<td>249,000</td>
<td>866,000</td>
<td>1,222,000</td>
</tr>
<tr>
<td><strong>Bénéfices économiques</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Support study for Impact Assessment of Cooperative Intelligent Transport Systems

<table>
<thead>
<tr>
<th>Impact</th>
<th>Option politique 1</th>
<th>Option politique 2</th>
<th>Option politique 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consommation de carburant réduite (1000 litres)</td>
<td>4,460 2,5 md €</td>
<td>20,084 11,2 md €</td>
<td>32,111 18,2 md €</td>
</tr>
<tr>
<td>Économie de temps de déplacement urbain (millions d'heures)</td>
<td>400 2,0 md €</td>
<td>2,174 10,8 md €</td>
<td>5,609 28,2 md €</td>
</tr>
<tr>
<td>Réduction des émissions de CO₂ (1000 tonnes)</td>
<td>12,000 0,7 md €</td>
<td>54,000 3,2 md €</td>
<td>87,000 5,3 md €</td>
</tr>
<tr>
<td>PM réduite (tonnes)</td>
<td>44 0,01 md €</td>
<td>-1,397 -0,039 md €</td>
<td>-3,029 -0,1 md €</td>
</tr>
<tr>
<td>NOX réduit (tonnes)</td>
<td>8,234 0,1 md €</td>
<td>29,878 0,2 md €</td>
<td>46,321 0,4 md €</td>
</tr>
<tr>
<td>COV réduit (tonnes)</td>
<td>1,518 0,002 md €</td>
<td>4,925 0,005 md €</td>
<td>7,343 0,008 md €</td>
</tr>
</tbody>
</table>

**Bénéfices environnemental totaux**: n/a 0,8 md € n/a 3,4 md € n/a 5,6 md €

**Bénéfices totaux**: n/a 20,3 md € n/a 78,9 md € n/a 128,9 md €

**Bénéfices nets**: n/a 15,4 md € n/a 59,8 md € n/a 96,5 md €
Outre les impacts quantifiés, plusieurs impacts qualitatifs ont été évalués. Celles-ci sont présentées dans le tableau 0 - 3.

**Tableau 0-3. Résumé des impacts indirects évalués qualitativement ou en dehors du cadre de modélisation, par rapport à la base de référence**

<table>
<thead>
<tr>
<th>Indicateur</th>
<th>Option politique 1</th>
<th>Option politique 2</th>
<th>Option politique 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impacts sur les usagers de la route vulnérables (VRUs)</strong></td>
<td>Aucun VRU - C-ITS services spécifiques. Impacts limités obtenus.</td>
<td>Les mécanismes de coordination du PO1 + et le financement du développement de services au-delà des services Day 1 contribuent à la mise en œuvre des services C-ITS du VRU.</td>
<td>Les mécanismes de coordination du PO1 + et le financement du développement de services au-delà des services Day 1 contribuent à la mise en œuvre des services C-ITS du VRU.</td>
</tr>
<tr>
<td><strong>Impacts sur la charge administrative pour les projets d’États membres et de déploiement</strong></td>
<td>Conformité facultative. Si les charges administratives étaient trop lourdes, les États membres et les projets choisisraient de ne pas se conformer et d’éviter des coûts élevés.</td>
<td>Les principaux coûts de conformité sont le respect de la certification et de la politique de sécurité et l’évaluation de la conformité. Les coûts risquent d’être très faibles par rapport aux coûts d’équipement pour les infrastructures.</td>
<td>Pas de frais supplémentaires en plus de ceux encourus en PO2.</td>
</tr>
<tr>
<td><strong>Part du secteur public / privé dans les coûts d’équipement PV 2020-2035</strong></td>
<td>La plupart des dépenses du secteur privé (76,9% des dépenses du secteur privé)</td>
<td>La plupart des dépenses du secteur privé (86,8% des dépenses du secteur privé)</td>
<td>La plupart des dépenses du secteur privé (91,2% des dépenses du secteur privé)</td>
</tr>
<tr>
<td><strong>Impacts sur l’emploi d’ici 2035</strong></td>
<td>Augmentation de l’emploi dans l’UE28 par rapport à la base de référence (+ 0,063%)</td>
<td>Augmentation de l’emploi dans l’UE28 par rapport à la base de référence (+ 0,011%)</td>
<td>Augmentation de l’emploi dans l’UE28 par rapport à la base de référence (+ 0,013%)</td>
</tr>
<tr>
<td><strong>Impacts de la recherche, l’innovation (R&amp;I) d’ici 2035</strong></td>
<td>Impact limité</td>
<td>Augmentation de l’activité R&amp;I grâce à une plus grande sécurité politique et réglementaire</td>
<td>Augmentation de l’activité R&amp;I grâce à une plus grande sécurité politique et réglementaire</td>
</tr>
<tr>
<td><strong>Impacts sur les PME</strong></td>
<td>Impact limité</td>
<td>Impacts positifs dus à une plus grande sécurité politique et réglementaire</td>
<td>Plus grand impact grâce à la sécurité politique et réglementaire et au déploiement amélioré</td>
</tr>
</tbody>
</table>

**Comparaison des options**

- **Option préférée:** La conclusion de cette étude est que l’option politique 2 est l’option privilégiée, sur la base d’une performance supérieure en termes d’efficacité, ainsi que de proportionnalité et de subsidiarité. Bien que l’option 3 ait la meilleure note d’efficacité et de cohérence, la sélection de l’option 2 n’empêche pas de passer à l’option 3 une fois que les avenues légales et politiques seront mieux comprises (et que les considérations de proportionnalité et de subsidiarité pourront être actualisées) la performance future sous PO2 est évaluée.

- **Efficacité:** L’option politique 3 est la plus forte dans presque tous les indicateurs par rapport aux trois objectifs spécifiques définis dans notre arbre à problèmes
et aux objectifs indirects concernant le déploiement et d'autres bénéfices indirects.

- **Efficience**: L'option 2 est le choix le plus efficace. Il y a un bond important dans la proportion des bénéfices nets entre Option 1 et 2 (une augmentation de 260 pour cent), alors qu'il y a une plus faible augmentation des bénéfices nets entre option 2 et 3 (une augmentation de 62 pour cent).

- **Cohérence**: L'option 2 offre une meilleure performance que l'option 1 en matière de cohérence. L'option 3 est légèrement supérieure à l’option 2 en ce qui concerne la cohérence. Pour cette raison, l'option 3 est le meilleur choix compte tenu l’information disponible.

- **Proportionalité et subsidiarité**: Les deux options politiques 1 et 2 sont proportionnées - permettant aux États membres de déterminer eux-mêmes leur niveau de déploiement. Les avantages accrus de l'option 2 sont proportionnels au niveau de contrôle délégué à l’UE par les États membres. L’option politique 3 impose une obligation directe aux équipementiers automobiles, ce qui entraîne des coûts (à la fois matériels et politiques). Étant donné que des avantages importants peuvent déjà être obtenus dans le cadre de l’option 2 sans imposer cette obligation, l'option 2 est jugée plus proportionnelle que l'option 3.

**Analyse de sensibilité**

L'étude a évalué trois sensibilités sur les options politiques afin de comprendre séparément les effets d’une augmentation de 50% des coûts d’équipement, d’une diminution de 10% des niveaux de déploiement projetés (sensibilité aux déploiement) et d’une diminution de 10% de l’efficacité attendue des services C-ITS (sensibilité aux impacts). Dans l’ensemble, les avantages nets cumulés entre 2020 et 2035 restent positifs pour toutes les options politiques, quelles que soient leurs sensibilités.

Le tableau 0-4 ci-dessous résume les résultats de la sensibilité aux coûts d’équipement.

**Tableau 0-4. Valeur actuelle nette (VAN) au titre des options politiques lorsque les coûts d’équipement augmentent de 50%**

<table>
<thead>
<tr>
<th></th>
<th>PO1 2020-2030</th>
<th>PO1 2020-2035</th>
<th>PO2 2020-2030</th>
<th>PO2 2020-2035</th>
<th>PO3 2020-2030</th>
<th>PO3 2020-2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAN bénéfices</td>
<td>5.0 bn</td>
<td>15.4 bn</td>
<td>20.4 bn</td>
<td>59.8 bn</td>
<td>36.8 bn</td>
<td>96.5 bn</td>
</tr>
<tr>
<td>VAN bénéfices avec augmentation</td>
<td>4.0 bn</td>
<td>13.5 bn</td>
<td>15.6 bn</td>
<td>51.5 bn</td>
<td>27.2 bn</td>
<td>81.8 bn</td>
</tr>
</tbody>
</table>

Les résultats de la sensibilité d'une diminution de 10% des niveaux de déploiement projetés (sensibilité aux déploiement) et d'une diminution de 10% de l'efficacité attendue des services C-ITS (sensibilité aux impacts) ont montré une diminution plus que proportionnelle aux avantages attendus, mais ont néanmoins produit des avantages nets significativement positifs:

- Au titre de l’option politique 1, les avantages cumulés nets actualisés entre 2020 et 2035 passent respectivement de 15,4 milliards d’euros à 11,2 milliards d’euros et 12,6 milliards d’euros au titre des sensibilités de déploiement et d’impact.
Pour l’option politique 2, les avantages cumulés nets actualisés sont passés de 59,8 milliards d’euros à 43,4 milliards d’euros et de 48,9 milliards d’euros au titre des sensibilités de déploiement et d’impact. Dans le cadre de l’option politique 3, les avantages nets passent de 96,5 à 85,5 milliards d’euros et de 80,7 milliards d’euros au titre de la sensibilité au déploiement et à l’impact.
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