European
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Pilot project on the design, implementation and execution of the transfer of GNSS data during an E112 call to the PSAP

Contract No 440/PP/GRO/PPA/15/8308

Deliverable D1.2 Analysis of the state of the art

HELP
112

Alexis Gizikis, Ismail Embabyl, Benoit Vivier, Cristina Lumbreras
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	Responsibility-Office-Company	Date	Signature
Prepared by	Alexis Gizikis, Ismail Embaby, Benoit Vivier, Cristina Lumbreras	30 May 2016	
Verified by	Tony O'Brien	30 May 2016	
Approved by	Gary Machado	30 May 2016	

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LIST OF ABBREVIATIONS

3GPP - 3rd Generation Partnership Project

A-GNSS - Assisted Global Navigation Satellite System

A2C - Authorities to Citizens communication

ACE - Accredited Center of Excellence

AML - Advanced Mobile Location

APCO - Association of Public Safety Communications Officials

API - Application Program Interface

BSC - Base Station Controller (2G)

BSSAP-LE - LCS Extension for Lb, Lp and Ls interfaces

BSSMAP-LE - BSSMAP LCS Extension

BSSLAP - BSS LCS Assistance Protocol

C&C - Command & Control

C2A - Citizens to Authorities communication

CAD - Computer-aided dispatch

CAPEX - Capital expenditures

CDMA - Code Division Multiple Access

CEN - European Committee for Standardisation

CEP - Circular Error Probability

CERN - European Organisation for Nuclear Research

CIRTT - Cell ID and Round Trip Time

CITA - Cell ID and Timing Advance

CITARX - Cell ID, Timing Advance and Received Signal levels

CMRS - Commercial Mobile Radio Service

CNES - French Space Agency

EC - European Commission

E-CID – Enhanced Cell ID

ECAS - Emergency Call Answering Service

ECC - Electronic Communications Committee

EE - British mobile phone operator, formerly Everything Everywhere

EGNOS - European Geostationary Navigation Overlay Service

EISEC - Enhanced Information System for Emergency Calls

ESA - European Space Agency

ESSN - Emergency Services Staff Network

ETC - Electronic Toll Collection

ETSI - European Telecommunications Standards Institute

EU - European Union

FP7 - Framework Programme 7

GIS - Geographical Information System

GMLC - Gateway Mobile Location Center

GNSS - Global Navigation Satellite System

GPS - Global Positioning System

GSM - Global System for Mobile Communications

HSS - Home Subscriber Server

ICE - In Case of Emergency

IETF - Internet Engineering Task Force

IOV - In-Orbit Validation

IP - Internet Protocol

IPR - Intellectual Property Right

IRSN - French Nuclear Safety Institute

Iupc - Interface between RNC and SAS (RNC interface)

IVE - in-vehicle equipment

IVS - in-vehicle systems

KPI - Key Performance Indicator

LAC - Location Area Code

LBS - Location based Services

LCS - LoCation Services

LCS-AP - LCS Application Protocol

LPP - LTE Positioning Protocol

LTE - Long-Term Evolution

LPP - LTE Positioning Protocol

MAC - Media Access Control

MEP - Member of the European Parliament

MLC - Mobile Location Centre

MME - Mobility Management Entity (4G)

MNO - Mobile Network Operator

MSD - Minimum Set of Data

MSG - Mobile Standard Group

MT-LR - Mobile Terminating Location Request

NBL - Network Based Location

NENA - National Emergency Number Association (US)

NG - Next Generation

NG112 - Next Generation 112

OPEX - Operating Expenditures

OS – Operating System

OTDOA - Observed Time Difference Of Arrival

PCAP - Positioning Calculation Application Part

PCO - Project Control Office

PEMEA - Pan-European Mobile Emergency Application

PSAP - Public Service Answering Point

R&D - Research & Development

RFPM – Radio Frequency Pattern Matching

RNC - Radio Network Controller (3G)

Rx - Received Signal level

RRLP - Radio Resource Location services Protocol

RTT - Round Trip Time

SAS - Standalone SMLC

SET - SUPL enabled terminal

SIM - Subscriber Identity Module

SIP - Session Initiation Protocol

SL - SUPL Location

SLA - Service Level Agreement

SLC - SUPL Location Center

SLP - SUPL location platform

SMLC - Serving Mobile Location Center

SMS - Short Message Service

SSID - Service Set IDentifier

SUPL - Secure User Plane

SV - Space Vehicle

TDOA - Time Difference of Arrival

TA - Timing Advance (between an MS and its serving BTS)

TL - Task Leaders

TLRR - Trigger Location Reporting Request

TM - Technical Manager

TOA - Time of Arrival

TTFT - Time To First Fix

WP - Work Package

WPL - Work Package Leader

UE - User Equipment (mobile)

UMTS - Universal Mobile Telecommunication System

URI - Uniform Resource Identifier

WGS84 - World Geodetic System Datum 84

VoLTE - Voice over LTE

1. INTRODUCTION

1.1 PLACE OF THIS DOCUMENT AND OBJECTIVES

This document is the "Analysis of the state of the art", identified as D1.2 in the list of project deliverables.

It is generated as part of the contract 440/PP/GRO/PPA/15/8308.

The objectives of the document are to:

- Analyse the existing implementations and available technologies for the provision of location information in every context
- Study all solutions regardless of their technology dependencies, such as 112 applications, advanced location solutions, advance network solutions and all the different methods to transmit the location such as SMS, data channel or eCall technology
- Report and review the accuracy and reliability of solutions, the time needed to deliver the location to the PSAP, and the availability of information regarding the method used to determine the location

The following chart defines the place of this document and its interaction with other work package deliverables.

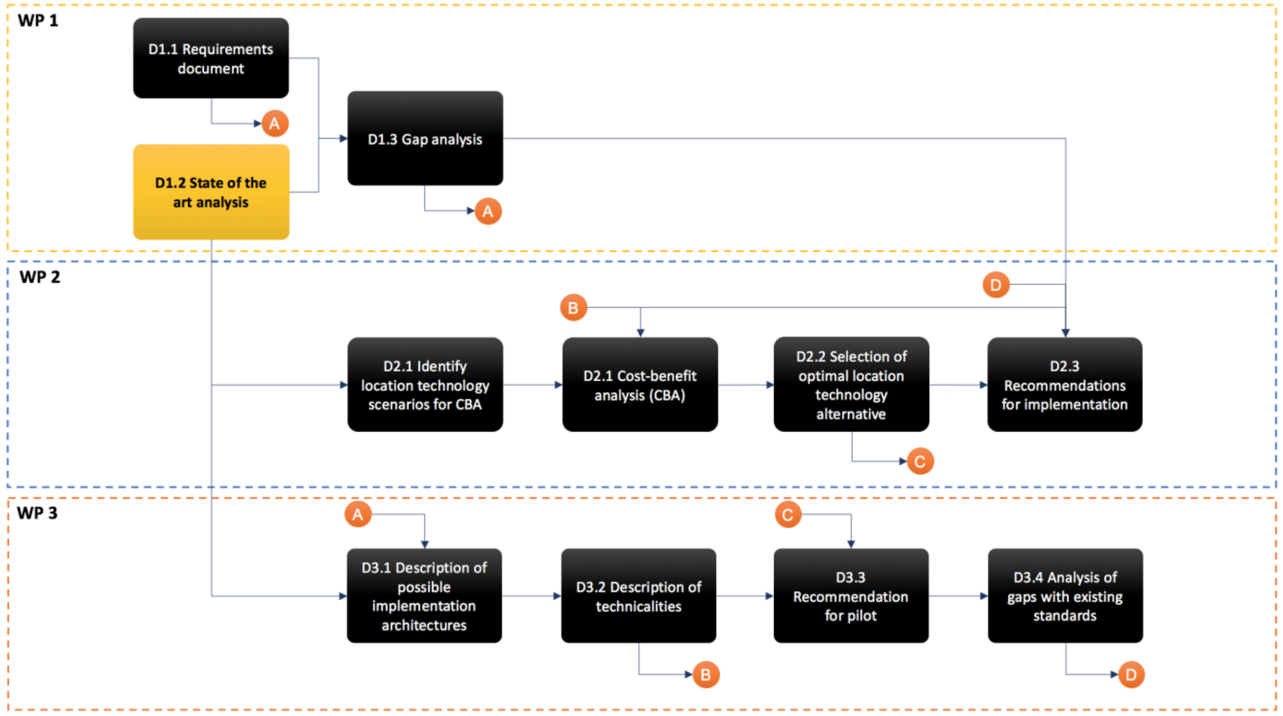

Figure 1: HELP112 Deliverable flow chart

The goals of each work package deliverables are:

- WP1:
    - D1.1: Defines the **user requirements and formulates a set of user scenarios** that will lead the implementation and evaluation of the architecture.
    - D1.2: Analyses and compares the **existing solutions and the underlying technologies** for the provision of caller location.

    - D1.3: Analyses how **existing solutions satisfy the requirements,** reports the **barriers for deployment** and provides **recommendations for the implementation.**
- WP2:
    - D2.1: Defines the **key location and transmission technology scenarios** and assess the **costs and benefits of each scenario.**
    - D2.2: Recommends **the optimal scenario(s) for the help112 caller location** based on the results of the cost-benefit analysis.
    - D2.3: Provides **a more detailed assessment of the costs linked to implementation of the selected technology scenario(s)** as well as **key operational and financial recommendations.**
- WP3:
    - D3.1: **Defines possible implementation architectures for the pilot sites**, covering location/transmission tech. alternatives of WP1.
    - D3.2: Describes **technicalities of these architectures** and recommendations for their implementation.
    - D3.3: **Selects the architecture to be deployed** for the pilots based on outputs of WP2.
    - D3.4: **Analyses the gaps between the selected architecture and the existing standards** (eCall, 3GPP, ECC-REP-225).

1.2 FOREWORD

Emergency caller location is the most important piece of information for both PSAPs and first responders. Ensuring it is accurate, reliable and timely will save lives and significant emergency services resources. Not having it will mean negative outcomes for our citizens.

In the absence of a detailed and prescriptive regulatory framework, emergency mobile caller location information in Europe has typically relied on Cell-ID. Often, Cell-ID is inadequate because the cell radius is too large, notably in rural areas.

Developments in location technologies and the proliferation of GNSS enabled smartphones are leading to improved location information being available in the handset. Making such handset derived positioning information available to PSAPs during emergency communications in a secure and reliable manner is highly desirable.

This consortium, known as the HELP112 consortium, aims to demonstrate that accurate and reliable caller location information is highly effective and is also highly efficient. It also studies possible deployment strategies across Europe in a cost effective manner, securing better outcomes for our citizens and simultaneously not placing any additional burden on the emergency services, mobile network providers or public authorities.

1.3 APPLICABLE DOCUMENTS

AD	Title of the document & reference
AD 1	Contract 440/PP/GRO/PPA/15/8308
AD2	Help112 Consortium Agreement

Table 1: Applicable documents

1.4 REFERENCE DOCUMENTS

RD	Title of the document & reference
RD 1	Help112 Technical, Management & Financial Proposal TPZF/SSA-T2015-PP-0451 is1.0 31/07/2015

Table 2: Reference documents

2. EXISTING IMPLEMENTATIONS OF CALLER LOCATION IN EUROPE

The caller location solutions currently available in most EU member states are based on Cell ID. Deliverable D1.1 Requirements Document reports that caller location by Cell ID lacks accuracy and precision, which is considered an unsatisfactory solution for emergency calls. The response time in the four pilot sites of HELP112 is short and satisfactory[1], while other countries encounter long response times, adding additional reasons for considering the existing Cell ID solution as inappropriate. Some states have deployed caller location solutions, such as 112 Apps and AML, in addition to Cell ID. Table 3 summarises the current location solutions in EU member states.

Country	Caller location method	Time needed for receiving the caller location by the 112 operator	Additional solutions (112 App, AML, etc.)
Austria	Cell ID or location of base station Sector ID if available	10 min	112 App available for some areas
Belgium	Cell ID	Almost immediately	No
Bulgaria	Cell ID / Sector ID	Instantly	No
Croatia	Cell ID and angle of coverage	10 – 20 sec	112 App
Cyprus	Cell ID	2 min	n/a
Czech Republic	Depends on the operator, varies from sector ID to large geographic area.	0.5 sec	No
Denmark	Cell ID	Instantly	112 App
Estonia	Cell ID	Instantly	No
Finland	Cell ID/Sector ID and also more accurate information based on the best available calculation method depending on the operator.	< 9 sec	112 App
France	Cell ID	About 10 minutes during working hours, less than 30 minutes outside working hours	No
Germany	Cell ID	n/a	No

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[1] *The response time for the pilot site in Austria is different from the response time reported in the table for Austria. The first relates to the PSAP(s) participating in the consortium and the later to other PSAPs in the country.*

Country	Caller location method	Time needed for receiving the caller location by the 112 operator	Additional solutions (112 App, AML, etc.)
Greece	Cell ID	7-30 minutes	No
Hungary	Cell ID	Instantly	No
Ireland	Cell ID	Almost immediately	No
Italy	Cell ID	4 seconds	112 App available for some areas
Latvia	Cell ID / Sector ID	Average time - 10 sec after the call is finished	112 App available for Emergency Medical Services
Lithuania	Cell ID / Sector ID	1 – 2 sec	112 App
Luxembourg	Cell ID	5 min	112 App
Malta	Cell ID	10 min	No
Netherlands	Cell ID and location of the antenna	< 1 sec	No
Poland	Cell ID	Real time	No
Portugal	Cell ID	Instantly	No
Romania	Cell ID / Sector ID	3 sec	No
Slovakia	Cell ID / Sector ID	n/a	No
Slovenia	Cell ID	3 sec	No
Spain	Cell ID	n/a	Some apps available
Sweden	Cell ID, with or without timing advance	1 sec	No
United Kingdom	Cell coverage areas, with, or increasingly without, timing advance	< 1 sec	AML

Table 3: Caller location solutions in Europe. Source: EENA Public Safety Answering Points in Europe[2]

The data in Table 3 are in agreement with the 2016 COCOM's report[3] "Implementation of European emergency number 112" and the ECC report 143[4] "Practical improvements in handling

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[2] *EENA, "Public Safety Answering Points in Europe, 2015 edition", November 2015, Annex 1, p. 231*

[3] *Communications Committee (COCOM), "Implementation of the European emergency number 112 – Results of the ninth data-gathering round", 11 February 2016, Annex, p. 10*

112 emergency call: caller location information". Only small differences are observed between the data found in latest and previous versions of the reports, showing that in the past few years very little has changed, while the emergence of 112 Apps has increased. Table 3 indicates that Cell ID is currently the main solution for caller location in the EU member states. Only nine member states use additional solutions, mainly 112 Apps, while only the United Kingdom uses AML. The ECC report 225[5] describes:

"*Mainly, mobile network operators do not have experience in Europe with more advanced positioning technologies in order to provide more accurate caller location information. In the vast majority of cases, only Cell-ID is currently provided and no plans and considerations are being given to improving accuracy at this time.*"

One of the main findings of the 2016 COCOM's report[6] confirms the lack of more accurate caller location:

"*No improvement is noticed on the implementation of more accurate caller location in Europe. Cell ID/Sector ID is a standard location requirement in Europe for mobile networks delivering accuracy between 30 meters and tens of kilometres.*"

"*In order to make the emergency intervention more efficient caller location should be provided together with the call to the emergency service. Still, excessively long time is needed to receive the caller location in France (several minutes), Malta (5- 10 minutes) and Greece (28min 58s).*"

Article 26.5 of the amended Universal Service Directive[7] states that "*Member States shall ensure that undertakings concerned make caller location information available free of charge to the authority handling emergency calls* ***as soon as the call reaches that authority***". The long response times reported in some member states, including France, Malta and Greece, raise important questions on whether Article 26.5 of the directive has been appropriately enforced. In Greece for example, the method used to "pull" the location information involves a written request from the PSAP to the respective network operator sent by fax. It should be noted that Austria did not report relevant data for this Key Performance Indicator in the 2016 COCOM report.

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[4] *ECC Report 143, "Practical improvements in handling 112 emergency call: caller location information", April 2010, section 9, p. 21*

[5] *ECC Report 225, "Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services", 21 October 2014, section 7.1, p.38*

[6] *Communications Committee (COCOM), "Implementation of the European emergency number 112 – Results of the ninth data-gathering round", 11 February 2016, Executive summary, p. 2 - 3*

[7] *Directives 2002/22/EC & 2009/136/EC*

3. CALLER LOCATION SOLUTIONS IN THE US

The regulatory authority of the United States, the Federal Communication Commission (FCC), has driven the implementation of caller location information for the majority of emergency calls originating from mobile devices. The regulatory requirements for network operators were introduced in 1996, when the FCC issued the Wireless Enhanced 911 Rules and outlined the implementation of caller location in two phases[8].

E911 Phase I[9]

Wireless network operators must provide to the PSAP the telephone number of the originator of a wireless 911 call and the location of the cell site or base station transmitting the call.

E911 Phase II

Wireless network operators are required to improve the caller location by providing the PSAP with the latitude and longitude of callers. Carriers can choose to use handset-based positioning using GPS, or networked-based positioning using cell-tower triangulation methods.

Phase II also defined the accuracy requirements of location information based on the type of positioning method. Location accuracy for handset-based positioning must be within 50 metres for 67% of calls and within 150 metres for 90% of calls. Location accuracy for network-based positioning must be within 100 metres for 67% of calls and within 300 metres for 90% of calls. The accuracy criteria were initially planned for 11 September 2008, but were deferred until 11 September 2012. The National Emergency Number Association (NENA) estimated the cost of nationwide Phase II at $8 billion with no established cost recovery mechanism[10].

In December 2015, NENA published the following statistics regarding the implementation of E911[11]:

- 99.1% of **PSAPs** have some **Phase I**
- 98.3% of **PSAPs** have some **Phase II**
- 97.1% of **Counties** have some **Phase I**
- 95.9% of **Counties** have some **Phase II**
- 98.8% of **Population** have some **Phase I**
- 98.5% of **Population** have some **Phase II**

NENA explains "*the term 'some' means that some or all wireless carriers have implemented either Phase I or Phase II service in the County or the PSAPs. In order for any carrier to provide service,*

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[8] *FCC website, "911 Wireless Services", https://www.fcc.gov/consumers/guides/911-wireless-services, accessed 26 April 2016*

[9] *FCC News Report No. DC 96-52, ""FCC adopts rules to implement enhanced 911 for wireless services", 12 June 1996, http://transition.fcc.gov/Bureaus/Wireless/News_Releases/1996/nrwl6026.txt, accessed 26 April 2016*

[10] *Industry Council for Emergency Response Technologies (iCERT), "History of 911 and what it means for the future of emergency communications", http://www.theindustrycouncil.org/publications/iCERT-9EF_Historyof911_WebVersion.pdf, accessed 26 April 2016*

[11] *NENA, "9-1-1 Statistics", http://www.nena.org/?page=911Statistics, accessed 26 April 2016*

the County or PSAP must be capable of receiving the service. In most cases, all carriers are implemented in a County or PSAP, but one or more may be in the process of completing the implementation". Although PSAPs can receive caller location and the statistics of Phase II implementation are above 95% in all cases, the first suggestion of the 911 tips to citizens is "*tell the emergency operator the location of the emergency right away*" [12].

Phase II accuracy requirements did not impose the use of specific technologies and allowed the network operators to choose their preferred technology, including both network and handset based approaches, or in some cases combinations of such approaches. In 2005, the FCC reports[13] that amongst the four largest national network operators, two operators, Sprint and Verizon Wireless, use A-GPS handset based positioning in their CDMA networks, while AT&T, formerly know as Cingular wireless, and T-Mobile use the TDOA network based location technology in their GSM networks.

In 2011, the FCC states[14], "*the wireless industry is engaged in a broad migration away from the dichotomy between network- and handset-based approaches to location accuracy*" and that "*the technological distinctions between handset- and network-based wireless E911 solutions will continue to diminish*". Network operators already using handset based A-GPS positioning were reported to improve location information with network based techniques and operators previously using network based techniques were reported to transition to A-GPS. The use of network based positioning was also reported to serve as fall-back caller location option, complementing A-GPS.

The continuously increasing availability of mobile devices introduced changes in the way people were using landline and mobile phones. The wide availability of mobile phones and the change of the calling habits resulted in a larger number of emergency calls from mobile phones from indoor locations. This imposed a new challenge for caller location requirements. Location accuracy by A-GPS positioning is optimised when used outdoors and can not provide as accurate results indoors due to the diminishing GNSS signals. Additionally, the need for vertical location emerged to allow first responders to determine the floor where the emergency call originated.

With the majority of emergency calls being placed from mobile phones, the FCC updated the E911 rules in 2015, with the objective to provide accurate location information of mobile callers, including indoors or outdoors and urban or rural areas.

The update was based on the "Roadmap for Improving E911 Location Accuracy"[15] that was agreed in November 2014 by the Association of Public Safety Communications Officials (APCO), the

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[12] *FCC website, "911 Wireless Services", https://www.fcc.gov/consumers/guides/911-wireless-services, accessed 26 April 2016*

[13] *FCC, "FCC AMENDED REPORT TO CONGRESS ON THE DEPLOYMENT OF E-911 PHASE II SERVICES BY TIER III SERVICE PROVIDERS", https://apps.fcc.gov/edocs_public/attachmatch/DOC-257964A1.pdf, 1 April 2005, p. 11, accessed 26 April 2016*

[14] *FCC, "NOTICE OF PROPOSED RULEMAKING, THIRD REPORT AND ORDER, AND SECOND FURTHER NOTICE OF PROPOSED RULEMAKING", 13 July 2011, p. 8, https://apps.fcc.gov/edocs_public/attachmatch/FCC-11-107A1.pdf, accessed 26 April 2016*

[15] *APCO, NENA, AT&T, T-Mobile USA, Sprint and Verizon Wireless, "Roadmap for Improving E911 Location Accuracy", 14 November 2014, http://c.ymcdn.com/sites/www.nena.org/resource/resmgr/GovAffairs/141114_Roadmap_for_Improving.pdf, accessed 26 April 2016*

National Emergency Number Association (NENA), and the four national wireless Commercial Mobile Radio Service (CMRS) providers, AT&T, T-Mobile USA, Sprint and Verizon Wireless. The FCC update initiated the need to use indoor positioning methods to deliver a dispatchable location[16] or an x/y coordinates location. Specifically, the FCC report and order[17] adopted the following rules:

Horizontal Location

All CMRS providers must provide (1) dispatchable location, or (2) x/y location within 50 meters, for the following percentages of wireless 911 calls within the following timeframes, measured from the effective date of rules adopted in this Order:

- *Within **2 years**[18]**: 40%** of all wireless 911 calls.*
- *Within **3 years**[19]**: 50%** of all wireless 911 calls.*
- *Within **5 years**[20]**: 70%** of all wireless 911 calls.*
- *Within **6 years**[21]**: 80%** of all wireless 911 calls.*

Vertical Location

All CMRS providers must also meet the following requirements for provision of vertical location information with wireless 911 calls, within the following timeframes measured from the Effective Date:

- *Within **3 years**: All CMRS providers must **make uncompensated barometric data available to PSAPs** from any handset that has the capability to deliver barometric sensor data.*
- *Within **3 years**: Nationwide CMRS providers must **use an independently administered and transparent test bed process to develop a proposed z-axis accuracy** metric, and must **submit the proposed metric to the Commission for approval**.*
- *Within **6 years**[22]: Nationwide CMRS provides must **deploy either (1) dispatchable location, or (2) z-axis technology that achieves the Commission-approved z-axis metric**, in each of the top 25 Cellular Market Areas (CMAs):*
    - *Where dispatchable location is used: the National Emergency Address Database (NEAD) must be populated with a total number of dispatchable location reference points in the CMA equal to 25 percent of the CMA population.*

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[16] *The roadmap document defines "dispatchable location" as "the civic address of the calling party plus additional information such as floor, suite, apartment or similar information that may be needed to adequately identify the location of the calling party".*

[17] *FCC, "Wireless E911 Location Accuracy Requirements, Fourth Report and Order", PS Docket No. 07-114, 29 January 2015, p. 3*

[18] *3 April 2017*

[19] *3 April 2018*

[20] *3 April 2020*

[21] *3 April 2021*

[22] *3 April 2021*

    - *Where z-axis technology is used: CMRS providers must deploy z-axis technology to cover 80 percent of the CMA population.*
- *Within* ***8 years***[23]*: Nationwide CMRS providers* ***must deploy dispatchable location or z-axis technology in accordance with the above benchmarks*** *in each of the top 50 CMAs.*

In addition, the updated rules adopted a 30 seconds limit on the time period allowed for a CMRS provider to generate a location fix in order for the 911 call to be counted towards compliance with existing Phase II location accuracy requirements that rely on outdoor testing. This time limit does not apply to the new indoor-focused requirements. Furthermore, CMRS providers are required to provide the percentage of wireless 911 calls to the PSAP that include Phase II location information and per-call identification of the positioning source method or methods used to derive location coordinates and/or dispatchable location, to any requesting PSAP.

The new FCC rules acknowledged that hardware and/or software changes might be needed on the handset to use nearby Wi-Fi or Bluetooth beacons and that "*the operating system of the handset will need to be configured to activate Wi-Fi and Bluetooth automatically, in the same manner that current GPS-capable handsets activate GPS automatically when the user calls 911*".

It should be noted that the new rules should be considered as complementary to the previous Phase II requirements that were solely focussing on determining outdoor caller locations. The report recognises that the final benchmarks to be adopted within six years may trigger a debate on replacing the Phase II requirements. The report explains:

"*The five and six-year benchmarks in the new rules, set to take effect in 2020 and 2021, will require 50-meter accuracy for 70 and 80 percent of all wireless 911 calls, respectively, and will apply to indoor and outdoor calls, thus exceeding the current Phase II handset-based standard of 50-meter accuracy for 67 percent of calls, based on outdoor measurements only. The last handset-based benchmark under the current Phase II requirements will occur in January 18, 2019. Thus, once the last Phase II benchmark has passed, we may revisit the issue of when to sunset date the current Phase II requirements and establish a unitary accuracy standard.*"

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[23] *3 April 2023*

4. METHODS TO ESTIMATE THE CALLER LOCATION

This section describes the methods available to estimate the caller location, isolated from the four caller location solutions for emergency call studied in HELP112, namely Network Based Location, AML, 112 Apps and eCall. The aim of this deliverable is not to describe them in technical depth, but to provide a description for the readers without a thorough technical background, including end users. Improving existing implementations for caller location in Europe requires an understanding of the available technical solutions by all stakeholders groups identified in section 3 of D1.1 Requirements Document.

Caller location can be estimated by measuring the radio parameters between the mobile handset on one side and either the mobile network or the satellite systems on the other side, in addition to WiFi access points. This categorisation follows the general considerations outlined in the ECC report 225[24] for "location information for mobile service":

"*The geographic location estimate of the mobile terminal is usually done by measuring specific parameters associated with radio signals exchanged between the mobile terminal and the mobile radio access network or the satellite system. Some alternative methods have been developed, driven by the market, using radio signals other than those standardised for the use of the mobile radio access network or the satellite system (e.g. Wi-Fi related radio signals).*"

4.1 METHOD CLASSIFICATION

Hence, a distinction can be made between:

- **Network based techniques or Network derived location**

  The mobile networks infrastructure is used to calculate the location of the handset. Network based techniques can be implemented without the need to have specific technologies or capabilities available on the handsets.

- **Handset based technologies or Handset derived location**

  The handset must be equipped with the appropriate hardware and software to calculate its location. In the case of a smartphone calculating its location, the required hardware and software is usually already available on the device, e.g. GNSS or WiFi chipset and software to use it available in the operating system. In these cases, a data connection to relevant online services may be needed.

- **Hybrid solutions**

  Hybrid solutions use a combination of methods to derive the location utilising different handset capabilities and network information.

This distinction is followed in most works studying caller location for emergency calls, such as the

- ECC report 225
- ECC report 143

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[24] *ECC Report 225, "Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services", 21 October 2014, section 7.1, p.38*

- EENA NG112 Technical Committee Document on "Handset Derived Location for Emergency Calls"
- EENA Operations Document on "Caller Location in Support of Emergency Services"

The following sections cover different positioning methods utilising both the handset and the network capabilities. There is a range of positioning methods, their accuracy and reliability are improving over time, while also new technologies become available as the network types improve (2G, 3G, 4G). The accuracy and precision of each method is influenced by variables related to the environment and the location type. For example, determining the location by GNSS requires a line of sight to available satellites, which may be easily available in outdoor rural locations, while cell density is lower than in urban locations.

In all location calculation methods, the capabilities of the mobile network play an important role. The mobile network can be used to provide assistance data to the handset to enable the location calculation in the case of WiFi or to reduce the response time in the case of A-GNSS methods. Additionally, network measurements can be used during the location estimation. Despite the multifaceted requirements in a range of location types and environmental factors, the availability of multiple positions methods provides a range of fall-back methods, when one method is not available.

4.1.1 Definition of accuracy

The definitions of accuracy and precision are provided in section 4.1.1 of D1.1 Requirements, but they are also included in this section for convenience.

The accuracy of caller location is defined in the European Communication's Committee (ECC) report 225[25]:

"*Accuracy represents the difference between the true value (of the real position supposed to be exactly known) and the value of the best estimated position obtained during a set of measurements, the estimation of which is usually represented by the mean value*."

The definition of the term accuracy refers to the relationship between precision of the forecast location and its accuracy, i.e. the extent to which this forecast matches the ground truth and is the definition adopted in this deliverable and the HELP112 project.

It is important to note that the degree of precision is what can be stated for various location methods. Whether this precision is accurate or not is subject to an audit. In other words, a GNSS position of 5 metre radius is precise. A Cell ID position shape of radius 1,000m is relatively imprecise. However, if the caller is within that shape, then the result can be considered to be accurate. Based on this definition and depending on the received level of precision, a method with low precision might produce a location that will be considered inaccurate, e.g. a GNSS position with 10 metres precision when the real location (ground truth) could be 20 metres from the estimate. Similarly, a method with higher precision might produce a location that will be considered accurate, e.g. a Cell ID position with 1,000 metres precision when the real location (ground truth) could be 900 metres from the estimate. In this respect, a positioning method

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[25] *ECC Report 225, "Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services", 21 October 2014, section 4.1, p.21*

providing low precision, but inaccurate estimates, is not necessarily a method not satisfying the requirements. In such cases, the levels of the precision and accuracy should be considered.

End users require location data that is both precise and accurate. This document therefore refers to "precision and accuracy" as the conjoined term "accurate" where appropriate, following the needs of PSAPs. When various location methods are described and the observed data that each generates towards PSAPs and their GIS systems, we are referring to best estimated location.

4.2 DATA ASSOCIATED WITH CALLER LOCATION

The terms "location information" and "caller location" is used repeatedly in the context of emergency calls and consequently in the HELP112 project and its deliverables. For the progression of the project from the stage of the comprehensive analysis to the implementation phases, it is important to define the data associated with these terms.

The ECC report 225[26] describes:

"*According to 3GPP definitions, Location Information consists of a number of relevant data such as geographic location estimate of the mobile terminal, its velocity, horizontal and vertical accuracy of the location and the time needed to provide the location estimate*"

Similarly the EENA Operations Document[27] on "Caller Location in Support of Emergency Services" defines that EENA members have concluded that the "*accurate location information received by PSAP should include: Latitude, Longitude, Altitude (optional), Street address (optional), Accuracy estimate (RMS), Speed, Direction, Timestamp*".

In eCall, a Minimum Set of Data (MSD) has been defined and it includes location information, as described in section 7.4.2.

Table 4 compares the data describe in different definitions. Note: Data from the eCall MSD not related to caller location originating from mobile phones, e.g. data related to the vehicle, have not been included.

Data	Term in ECC report 225	Term in EENA Operations Document	Term in eCall MSD
Geographic Location	Geographic location estimate	Latitude, Longitude, Altitude (optional)	Latitude, Longitude
Velocity	Velocity	Speed	

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[26] *ECC Report 225, "Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services", 21 October 2014, section 7.1, p.38*

[27] *EENA Operations Document, "Caller Location in Support of Emergency Services", 19 November 2014, section 6.8, p. 21*

Data	Term in ECC report 225	Term in EENA Operations Document	Term in eCall MSD
Accuracy	Horizontal and vertical accuracy	Accuracy estimate (RMS)	Confidence in position
Time of positioning	The time needed to provide the location estimate	Timestamp	Timestamp
Other location data	n/a	Direction, Street address (optional)	Direction

Table 4: Caller location data. Source: Multiple sources indicated in the table header

ETSI 3GPP TS 22.071[28] defines velocity as the combination of speed and direction of a target UE.

The time of positioning is important for emergency services to find out if the location is recent.

4.3 NETWORK BASED POSITIONING

This section describes the different positioning methods available through a mobile network.

4.3.1 Cell ID

Cell ID positioning simply returns the geographic position of the area covered by the device's serving cell. This area is dependent on the angle of coverage and cell radius. The latter can vary from 550 meters to several kilometers. Important note: the serving cell is not necessarily the closest cell tower from the caller.

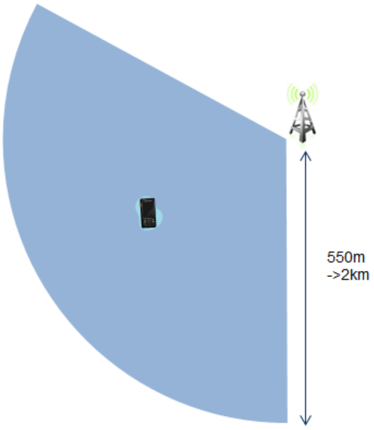

Figure 2: Cell ID precision level

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[28] *ETSI 3GPP TS 22.071 V14.1.0 (2015-09) Release 14*

4.3.2 2G - CITA

CITA is an abbreviation for Cell ID and Timing Advance. With the addition of timing advance, the device may be located within a 550m band within the serving cell.

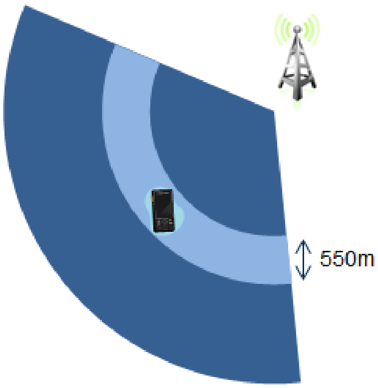

Figure 3: CITA precision level

4.3.3 2G - CITARx

CITARx is an abbreviation of Cell ID, Timing Advance and Received Signal levels. With the addition of received signal strengths from the co-sited cells, the position of the device may be calculated and a more precise position calculated along the given TA band.

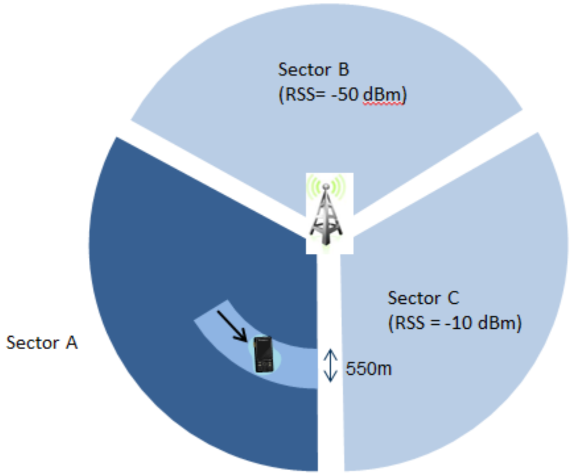

Figure 4: CITARx precision level

4.3.4 2G – RF Pattern Matching (RFPM)

The RF Pattern Matching positioning method is based on radio link measurements collected from the network and/or the mobile terminal. The method relies on predictions or models of the radio environment against which it performs an algorithmic comparison of the measurements to determine a best match estimation of the mobile terminal location. RFPM may utilise measurements other than the path loss measurements noted above, e.g. RTT or TA.

Figure 5: RFPM precision level

4.3.5 3G - CIRTT

CIRTT is an abbreviation of Cell ID and Round Trip Time. In UMTS (3G) networks a Round Trip Time parameter is returned. With 3GPP Release 9 the timing measurement has ben enhanced, so that there are now Type 1 and Type 2 measurement.

This parameter allows the calculation of approx 75m band for Type 1 and approx 35 m band for Type-2 within the serving cell as shown.

For 3G, neighbouring cells also return the RTT parameter. Note that the equivalent parameter, TA, is not returned for neighbouring cells in 2G networks. This additional information allows for a multilateration calculation and hence a much greater precision. For multilateration algorithms data is required from multiple cells from the Active, Monitored or Detected sets as described in 3GPP 25.453.

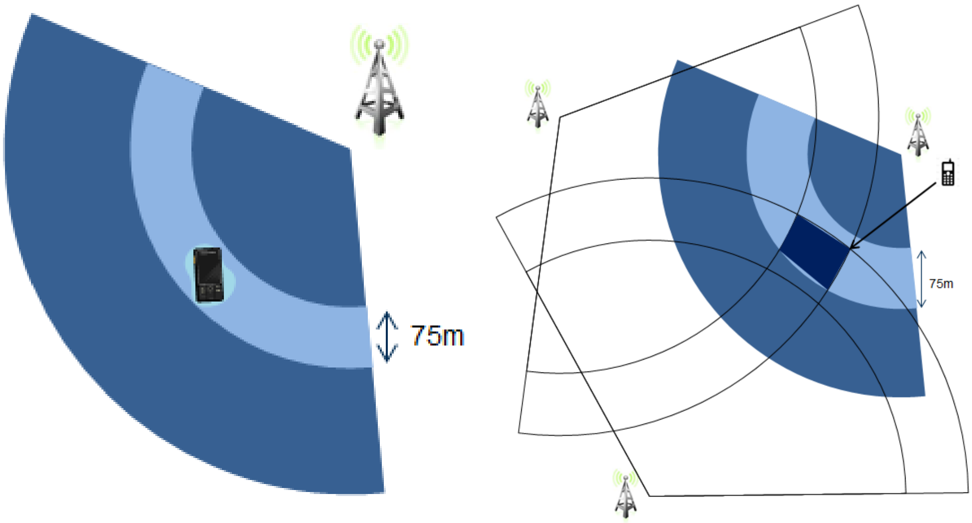

Figure 6: CIRTT precision level

4.3.6 4G - CITA

CITA is an abbreviation of Cell ID and Timing Advance. In LTE (4G), one of the position estimation methods is E-CID. This method can be executed in the following ways:

- E-CID - estimating distance from one base station

  Either RTT, Reference Signal Received Power or TA measurement value from Cell of origin is used in this method to estimate the distance of UE.

- E-CID - estimating the distance from multiple base stations

  In this method, the measurement values from multiple base stations are computed to perform Multilateration.

4.3.7 4G - OTDOA

Observed Time Difference Of Arrival (OTDOA) parameters are also availabale from LTE networks. The measurement of this parameter is more accurate than that for ECID and therefore once the multilateration calculation are computed, the returned accuracy is correspondingly greater.

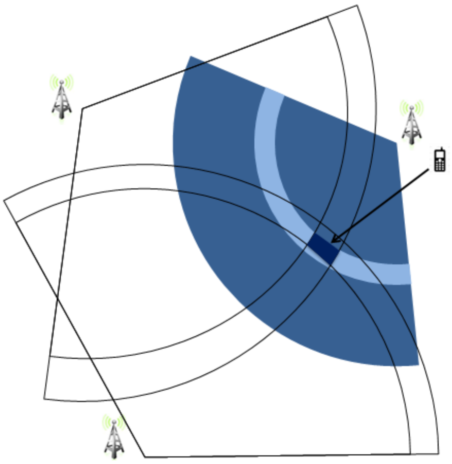

Figure 7: OTDOA precision level

4.3.8 CONTROL PLANE A-GNSS SOLUTION

The GMLC could support control plane based A-GNSS positioning. For a control plane based A-GNSS solution, SMLC/SAS will periodically interact with third party satellite reference node to obtain assistance data.

4.3.8.1 2G

In 2G networks, the SMLC will establish RRLP based interface towards the BSC to interrogate the handset capabilities and send assistance data to the handset if applicable.
Handset will utilize the assistance to either perform location estimates itself or return GNSS measures via BSC to SMLC.

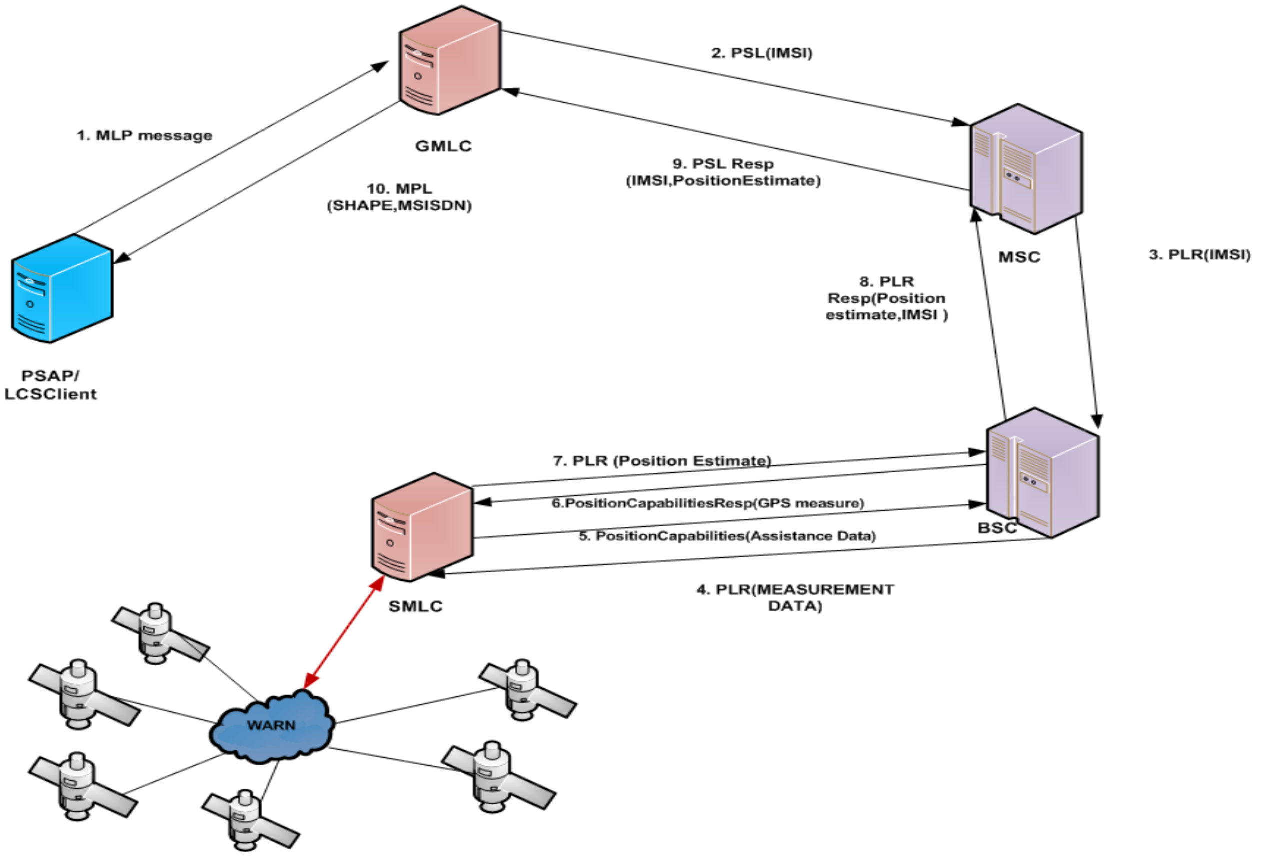

Figure 8: A-GNSS Message Flow in GSM Network

4.3.8.2 3G

In 3G networks, SAS will provide the assistance data to the handset via RNC on IUPC interface using PCAP protocol. Handset will utilize the assistance to either perform location estimates itself or return GNSS measures via RNC to SAS.

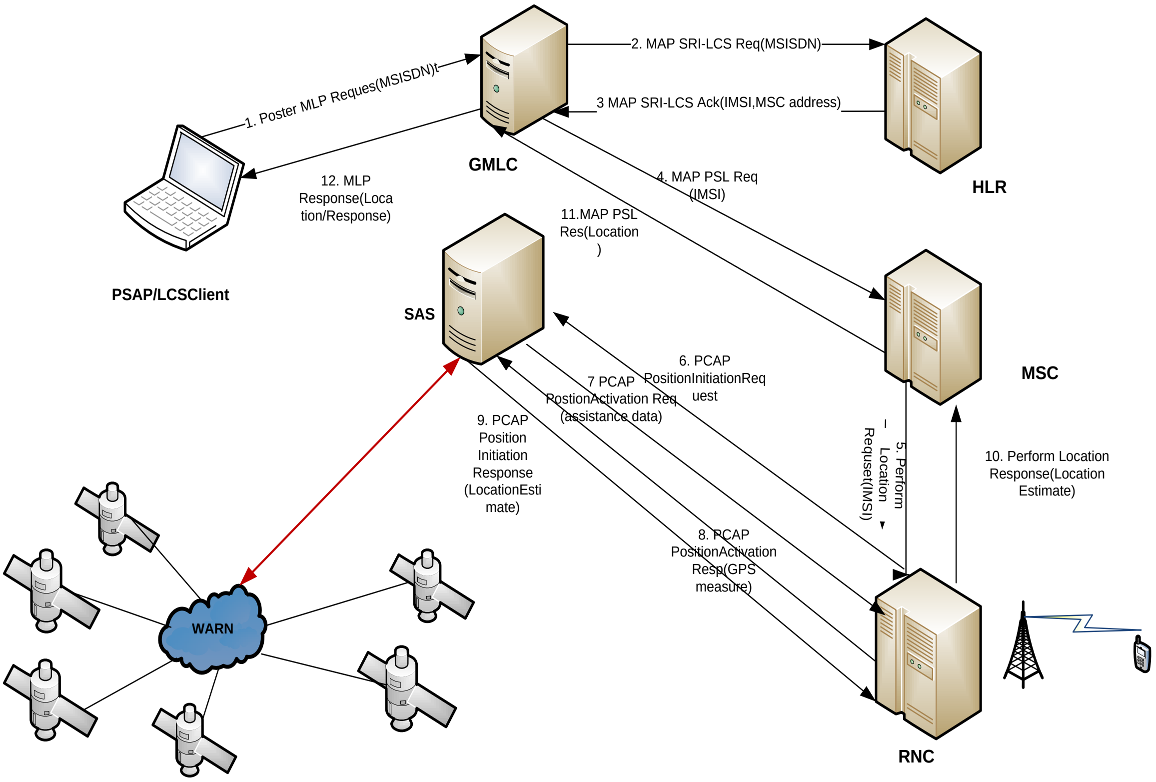

Figure 9: A-GNSS Message Flow in UMTS Network

4.3.8.3 4G

In a LTE network, the E-SMLC will provide the assistance data to the handset via MME on SLs interface using LCS-AP/LPP protocol. The handset will utilize the assistance to either perform location estimates itself or return GPS/GNNS measures via MME to E-SMLC.

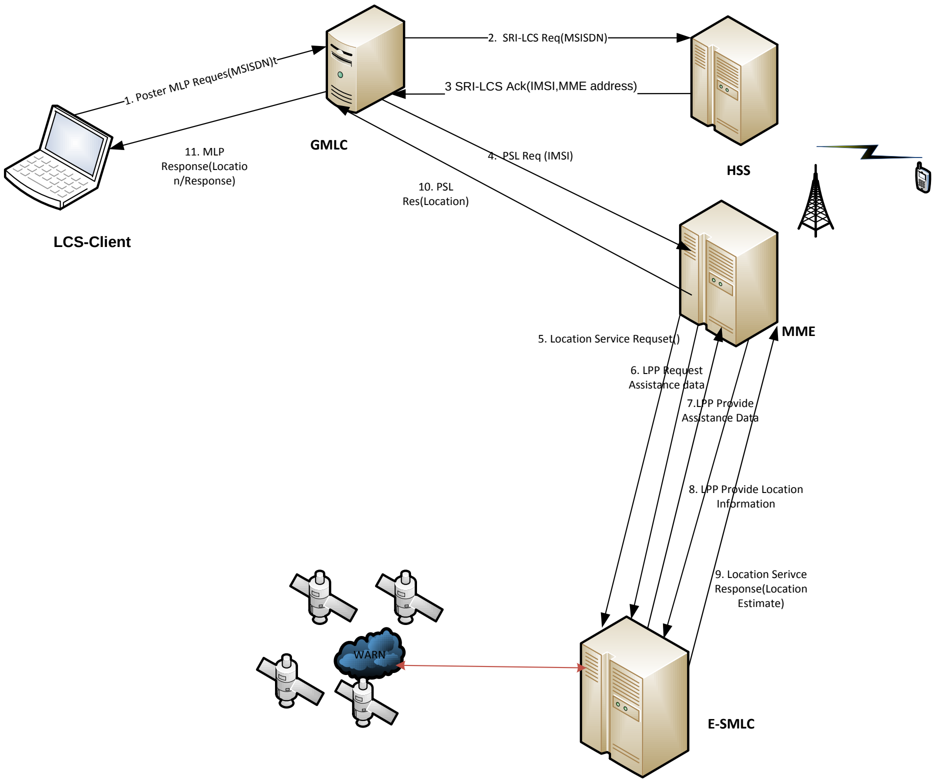

Figure 10: A-GNNS Message Flow in LTE Network

1. LCS-Client (i.e. PSAP) initiates locate request to the GMLC.
2. The GMLC queries the HSS for MME address
3. GMLC then sends a Provide Subscriber Location request to the serving MME.
4. The MME requests the e-NodeB to which the target is currently attached for location estimates.
5. MME sends Location Service request to the e-SMLC.
6. E-SMLC queries the handset capabilities by exchanging connection-oriented/connection-less LPP messages, and if applicable requests for assistance data via MME.
7. E-SMLC sends LPP Provide Assistance Data to UE.
8. If the handset has A-GNSS capabilities then MME returns back to E-SMLC the GNSS estimates from the handset in LPP Provide Location Information.
9. E-SMLC then calculates the Location estimates if required and sends the result to MME in Location Service Response message.
10. MME forwards the location estimates to GMLC
11. GMLC then sends the location result of the target to the LCS-Client (i.e. PSAP) in MLP response.

4.3.9 Advantages and disadvantages

The list here below presents the advantages of Network based location calculation:

- Handset independent.
- User independent.
- Technology independent – available today on 2G, 3G and 4G.
- No impact on battery life.
- Very fast processing time – location can be available in 2 seconds.
- Available in all environments and provides different levels of location precision (50m to few kilometres) depending on the network cell density. Hence, typically higher precision in dense urban when compared to rural areas.
- 3GPP standard based – hence smooth integration with Mobile Networks.
- Can't be stopped or hindered by the mobile user - it - transparently – functions on radio measurements automatically exchanged between the mobile network and all handsets.

Here below the list of disadvantages of Network based location calculation:

- Requires integration with Mobile Network: hence cooperation in terms of time and efforts from the mobile operator is required.
- Requires cooperation from the Network vendors, by enabling/opening the standard interfaces to connect the location calculation nodes with the mobile network elements. The Network vendors may charge for the interfaces.
- Lower accuracy when compared to GNSS-based location.

4.4 GNSS

GNSS is the "Global Navigation Satellite System" and "refers to a constellation of satellites providing signals from space transmitting positioning and timing data"[29], providing global coverage. GNSS includes the USA's NAVSTAR Global Positioning System (GPS), Russia's Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS) and Europe's Galileo.

The European GNSS is the Galileo system, currently having twelve deployed satellites[30] and aiming to be fully operational by 2020. Galileo's initial services are planned to be made available by the end of 2016[31]. EGNOS is the European Geostationary Navigation Overlay Service and is an operational satellite-based augmentation system compensating for certain disadvantages of GNSS concerning accuracy, integrity, continuity and availability[32]. EGNOS is currently improving the open

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[29] *EGNOS Portal, European GSA, http://egnos-portal.gsa.europa.eu/discover-egnos/about-egnos/what-gnss accessed 1 March 2016*

[30] *European Space Agency website, "Two more Galileo satellites poised for launch in May", http://www.esa.int/Our_Activities/Navigation/The_future_-_Galileo/Launching_Galileo/Two_more_Galileo_satellites_poised_for_launch_in_May, 26 February 2016, accessed 15 March 2016*

[31] *European Space Agency website, "What is Galileo", http://www.esa.int/Our_Activities/Navigation/The_future_-_Galileo/What_is_Galileo, accessed 4 March 2016*

[32] *EGNOS portal, "What is SBAS?", http://www.egnos-portal.eu/discover-egnos/about-egnos/what-sbas, accessed 4 March 2016*

public service offered by GPS and makes it suitable for safety critical applications such as aviation, maritime and other location based services[33]. When fully operational, Galileo and EGNOS are expected to improve caller location by offering greater location accuracy, availability and TTFF than the American and Russian systems. A wide range of locations will be supported, such as urban canyons with high rise buildings obscure signals from today's satellites and rural areas with fewer cells available than in an urban environment[34,35].

The number of GNSS enabled smartphones connected in Europe in 2014 is estimated to be 426 million[36], while the European provisional estimated population[37] is 507 million, resulting in approximately 84% of the population having a connected smartphone and assuming only one handset per person. During the public hearing run by the European Commission in Brussels, on 7th May 2014, Justyna Redelkiewicz of the European GNSS Agency (GSA) mentioned[38], "*Today there are some 426 million smartphones in Europe and there is a growing trend towards integrating various location technologies such as mobile cell id, GNSS and Wi-Fi into these devices. In addition, the use of multi-constellation GNSS is rapidly becoming the baseline for improved accuracy, availability and 'time to first fix'.*"

4.4.1 GNSS positioning

The European GSA provides a detailed explanation how GNSS positioning and navigation works:

"The basic principle underpinning satellite positioning is the use of distance measurements at a precise moment in time between a receiver and several navigation satellites whose exact positions in space are known.

The satellites emit electromagnetic waves which are propagated through space at the speed of light. It is then possible to calculate the distance separating the satellite from the receiver by determining the time a wave takes to travel from satellite to receiver using a mathematical formula: $d = c * t$, where d is the distance, c the speed of light and t the time it takes for the wave to travel from satellite to receiver.

To estimate the time that signals take to travel between a given satellite and the receiver, the receiver compares a unique code linked to the satellite's navigation signal with a copy of the same code generated by the receiver itself. Since the time interval between the codes corresponds to

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[33] EGNOS portal, "About EGNOS", http://www.egnos-portal.eu/discover-egnos/about-egnos, accessed 4 March 2016

[34] GSA website, "Galileo Benefits", http://www.gsa.europa.eu/galileo/benefits, accessed 4 March 2016

[35] Fiammetta Diani, Justyna Redelkiewicz, European GNSS Agency, "Galileo value proposition for emergency caller location (E112), 7 May 2014, slides 13, 18

[36] Fiammetta Diani, Justyna Redelkiewicz, European GNSS Agency, "Galileo value proposition for emergency caller location (E112), 7 May 2014, slide 9

[37] Eurostat, "Population on 1 January 2014", http://ec.europa.eu/eurostat/tgm/table.do?tab=table&language=en&pcode=tps00001&tableSelection=1&footnotes=yes&labeling=labels&plugin=1, accessed 1 March 2016

[38] GSA website, "How to Enable Better Location for Emergency Calls: Galileo and 112", 14 May 2015, http://www.gsa.europa.eu/news/how-enable-better-location-emergency-calls-galileo-and-112, accessed 1 March 2016

the transit time, this can then be used to calculate the distance, or 'pseudorange'. The use of 'pseudo' in this term is because this distance does not correspond to the geometric distance between satellite and receiver due to the bias between the time reference used by the GPS system and that used by the receiver. With at least three distance measurements to three different satellites it is theoretically possible to determine the position of the receiver if and only if the receiver's clock is perfectly synchronised with those on board the satellites.

Since a 1 millisecond difference between a satellite clock and receiver clock can produce a 300km positioning error, this clock bias must be compensated for. That is why distance measurements are made to a fourth satellite in order to calculate the bias."

The emergence of handsets supporting multiple GNNSs has enabled an opportunity to achieve greater accuracy and wider availability of caller location in a range of location types. The ECC report 225 describes:

"*The mobile terminal may support one or several GNSSs. In particular, a recent market trend refers to the employment of multi-GNSS receivers (i.e. receivers able to simultaneously track different GNSS). Such trend, enabled by the entering into the market of additional GNSS is justified by the fact that multi-GNSS receivers allow for a greater accuracy and availability of the achieved position in challenging situations (e.g. dense urban, deep forest, challenging mountainous environments), being more satellites in view."*

Mobile handsets can estimate their location by operating in two modes. In autonomous mode, the handset operates calculates it position from the satellite signals (GNSS positioning), while in assisted mode, it receives assistance data from the network and then calculates it position from the satellite signals. Assisted mode defines the A-GNSS positioning method. The assistance data enable the handsets to acquire satellite signals and calculate the position in less time. A-GNSS have significantly reduced Time To First Fix (TTFT). TTFF is the time needed for a GNSS receiver to compute a fix (position).

In the context of eCall, a theoretical and practical study was conducted in a real situation on the combination of motorways and regional roads in northern Croatia to assess the performance of GPS. The findings show that the use of a single position estimation method results in lack of performance and may cause potentially dangerous effects on emergency operations. The study proposes the improvement of accuracy by methods that provide more robust and accurate position estimation such as A-GNSS and EGNOS[39].

Furthermore, two modes of operation[40] can be identified in A-GNSS positioning:

- In the **terminal assisted** mode, the handset performs GNSS measurements and then sends the raw measurements to a location server. The location server calculates the position based on the measurements of the handset calculation and possibly by using additional measurements from other non GNSS sources.

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[39] *Renato Filjar, Gérard Segarra, Ilinca Vanneste, Pavao Britvic, Krešimir Vidovic, "Satellite positioning for eCall: an assessment of GPS performance",* http://www.heero-pilot.eu/ressource/static/files/filjar_segarra_vanneste_britvic_vidovic_rev_b.pdf

[40] *ECC Report 225, "Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services", 21 October 2014, section 7.2.6, p.42*

- In the **terminal based** mode, the handset performs GNSS measurements and calculates its location. Use of additional measurements from other non GNSS sources is also possible.

4.4.2 Transmission of assistance data

Two alternative architectures can support the transmission of assistance data: the Control Plane and User Plane architectures.

In the control plane architecture, the handset uses the mobile network's signal channels to communicate with the location server, assuming that the network supports this transmission. When the required network infrastructure and protocols are available, the use of the signal channel supports a broad range of locations. The ECC report emphasises:

"*It is important to mention that, in the context of emergency calls, control plane A-GNSS implementations allow operators to provide the location information of the mobile terminal, to the PSAPs, regardless of the existence of a valid data subscription. This means that a mobile terminal without a data subscription can still be located as the data service it is not used in the positioning process.*"

In the user plane architecture, the handset communicates with the location server over the mobile network's data channels. In this case, no specific network infrastructure and protocols are required.

4.4.3 Multi-constellation GNSS

Multi-constellation mass market GNSS can provide a better performance that single constellation GNSS. An average accuracy of 5 - 10 meter location in the cities and less than 5 meters in rural areas (outdoor; even without assistance data) can be expected by the use of GPS and Galileo[41]. The use of multi constellation GNSS is expected to also decrease the TTFF.

The tests conducted in May – June 2014 examined how Galileo contributes to better accuracy by comparing performances between GPS only and GPS+Galileo. Table 5 shows the average Horizontal Position Error (50% CEP – Circular Error Probability) of GPS and GPS + Galileo in different location types and Table 6 shows the average TTFF. The European GSA has shared the data provided in the tables with the HELP112 consortium[42].

	Average Horizontal Position Error (50% CEP)		**Best case Horizontal Position Error (50% CEP)**	
	GPS only	**GPS + Galileo**	**GPS only**	**GPS + Galileo**
Urban	5.60 m	4.86 m	4.7 m	3.9 m

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[41] *Fiammetta Diani, Justyna Redelkiewicz, European GNSS Agency, "Galileo value proposition for emergency caller location (E112), 7 May 2014, slide 13*

[42] *ESA MEMO, "Testing Results of the Galileo ready Mass-Market chips campaign for TLC operators", 24 March 2016*

	Average Horizontal Position Error (50% CEP)		Best case Horizontal Position Error (50% CEP)	
	GPS only	GPS + Galileo	GPS only	GPS + Galileo
Suburban	3.96 m	3.86 m	3.3 m	3.2 m
Motorway	2.73 m	2.70 m	2.6 m	2.5 m

Table 5: Average Horizontal Position Error (50% CEP – Circular Error Probability) of GPS and GPS + Galileo in different location types. Source: GSA

CEP refers to the radius of a circle containing 50% of the position estimates, i.e. in a 5 metre horizontal error, 50% of the estimated positions should be within 5 meters of the ground truth. It should be noted that the added value provided by Galileo is limited by the fact that only four satellites were available when the tests were conducted and only three satellites were used in each test, while in 2016, the constellation includes 11 operational satellites and the performance gain is expected to be higher.

In urban locations, the improvement due to additional Galileo in-orbit validation (IOV) satellites is 0.8 m on average, while in suburban and motorway scenarios the improvement is negligible. The memo provided by the GSA quotes that "*the combination GPS + GLONASS, with 7 - 8 GLONASS SVs (space vehicles) in view against the 2-3 Galileo IOVs, leads to an average horizontal position error of 4.68 m, very similar to the one achievable with GPS and Galileo (4.86 m)*". The above performance indicator is highly satisfactory for the E112 calls, especially when compared to the present situation of location information estimated by Cell ID, assuming also an acceptable reliability performance.

	Average TTFF		TTFF at 95% of the distribution	
	GPS only	GPS + Galileo	GPS only	GPS + Galileo
Urban hot start	4.25 s	4.03 s	10.38 s	9.14 s
Urban cold start	77.20 s	71.90 s	202.3 s	180.1 s

Table 6: Average hot and cold start TTFF of GPS and GPS + Galileo in urban environments. Source: GSA

The average improvement during the test is approximately 1 second in hot start and 20 seconds in cold start. The memo states that "*the contribution at least in cold start case average TTFF is expected to be much higher when the number of Galileo satellites in view is greater or equal to 4*".

Table 7 provides estimates of accuracy and TTFF that can be achieved by different GNSS positioning methods. EA stands for "Enhanced Assisted" and refers to GNSS and EGNOS assistance data received by the handset via the mobile network.

Positioning method	Accuracy	TTFF	Availability
EA-GPS - Outdoor	3.1 m	7.4 sec	100%
EA-GPS Deep Urban Canyon	14.5 m	19 sec	100%
EA-GPS Light Indoor	6.4 m	10.2 sec	100%
EA-GNSS (GPS+Galileo+Glonass) outdoor with Fine time assistance	2.9 m	1.8 sec	100%

Table 7: Accuracy, TTFF and availability estimates for different GNSS positioning methods. Source: Thales Alenia Space[43]

Other tests conducted in 2014, by Rx Networks Inc[44] and the GSA[45] showed the performance of Galileo in combination with GPS and GLONASS, in locations where GNSS positioning performance is degraded, such as urban canyons and indoor locations. Table 8 provides an overview of the accuracy of different combinations of GNSS constellations. The GPS row shows the absolute 2d errors in metres. All other rows show the improvement (+) or degradation (-) in metres and percentages relative to GPS-only fixes. All measurements are within the 95th percentile.

	Urban Canyon #1	Urban Canyon #2	Indoor #1	Indoor #2
GPS	182.3 m	46.1 m	243.7 m	83.2 m
GPS+GLONASS	26.9 m (15%)	4.9 m (11%)	73.3 m (30%)	9.8 m (12%)
GPS+Galileo	3.6 m (2%)	-0.1 m (0%)	3.1 m (1%)	8.6 m (10%)
GPS+GLONASS+Galileo	35 m (19%)	8.1 m (17%)	76.6 m (31%)	16.2 m (19%)

Table 8: Horizontal accuracy of Galileo in combination with GPS and GLONASS in urban and indoor locations. Source: GSA

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[43] *Michel Monnerat, Bruno Gagnou, Thales Alena Space, "GNSS and E112, EC Hearing", May 2014, slide 6*

[44] *Rx Networks Inc. website, "Test confirms that Galileo increases the accuracy of location based services", http://rxnetworks.com/test-confirms-that-galileo-increases-the-accuracy-of-location-based-services/, accessed 25 April 2016*

[45] *GSA website, "The Results are In: Galileo Increases the Accuracy of Location Based Services", http://www.gsa.europa.eu/news/results-are-galileo-increases-accuracy-location-based-services , accessed 25 April 2016*

The test results do not show significant accuracy improvement of GPS+Galileo in comparison to GPS+GLONASS due to the limited number of Galileo satellites available during the tests. However the test results show that using multi-constellation GNSS provides more precise location estimations compared to GPS only. With the availability of more Galileo satellites the precision of the location fixes is expected to increase significantly even in the most challenging environments for GNSS positioning, such as urban canyons and indoors.

4.4.4 Advantages and disadvantages

Considering the increasing availability of GNSS receivers in smartphones, GNSS positioning offers an opportunity to improve caller location for emergency calls originating from mobile devices. GNSS positioning is a form of terminal based location and has several advantages[46,47]:

- Highest level of accuracy in all outdoor location types
- Great availability at rural areas where network based location provides low precision, because of lower cell density
- High accuracy and availability levels in remote areas such as mountainous environments attracting tourists for outdoor activities, resulting in difficulties to verbally report the location
- Cost effective, being (mainly) handset-based and the cost of receivers now negligible
- Easy to deploy – already available on smartphones

The disadvantages of GNSS positioning:

- Requires a reasonably unobstructed view of the sky depending on location type, degrading performance in indoor locations and urban canyons
    - Enhanced indoor penetration, improved performances in urban canyons, better performances in noise measurements and improved sensitivity in A-GNSS mode are expected by the use of data-less signal of Galileo
    - Use of multi-constellations, e.g. GPS and Galileo, reduces the dependence on clear sky view and can provide an average of 5 - 10 metres of accuracy in the cities and less than 5 meters in rural areas and outdoors even without assistance data
- Accuracy level depends on the handset hardware, but it is more accurate than other positioning methods
- Requires download and use of a smartphone App, except for solutions that incorporate the location calculation in the OS or the manufacturer’s software
- Available on smartphones or higher end feature phones
- The user may have switched off the use of GNSS
- Depends on increased processing time and requires more battery power

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[46] *ECC Report 225, “Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services”, 21 October 2014, section 7.6.1, p.49*

[47] *Fiammetta Diani, Justyna Redelkiewicz, European GNSS Agency, “Galileo value proposition for emergency caller location (E112), 7 May 2014, slides 13, 14, 15, 16, 18*

- Longer response time compared to other positioning methods

4.5 WI-FI

Wi-Fi positioning uses information on the handset about the availability of nearby wireless access points, including Service Set IDentifier (SSID), the identifier of the Wi-Fi network, and the Media Access Control (MAC) address, the identifier of the network interface. Wi-Fi supports different location methods, such as methods based on the Received Signal Strength Indicator (RSSI) and fingerprinting. RSSI based methods use signal measurements to convert the signal strength to a distance from the access point. Fingerprinting is an RSSI based method and additionally used a location database, which contains references to Wi-Fi networks and their actual geographical coordinates. Using RSSI methods, the device first calculates its distance from Wi-Fi access points. Given the distance indicator, the device then uses the data from location database to calculate its geographical position[48,49].

Wi-Fi positioning solution is based on a service providing and maintaining a database of Wi-Fi access point MAC addresses and their precise locations. Access to service from mobile devices is generally enabled through API licencing with the main OS providers[50]. Wi-Fi access point locations may have been determined originally from a site survey or a drive by or walk by survey or by crowdsourcing of WiFi measurement data by many terminals whose locations could be established independently such as using GNSS, A-GNSS or OTDOA[51].

4.5.1 Advantages and disadvantages

Wi-Fi location accuracy depends on the number of access points in an area. Wi-Fi positioning provides an opportunity to calculate a position in certain location types with a high concentration of access points, such as urban areas, buildings and other indoor locations where GNSS positioning is not possible or provides less accurate locations. However, it is not an appropriate method for caller's location in other areas with less access point concentration, such as motorways or remote locations. EENA’s operations document[52] describes:

"*However, because it works indoors and offers a very fast time to first fix in urban environments, Wi-Fi is well placed to be part of the location mix available to application developers. We believe that since the technology is available, indoor location should be part of the expectation of E112.*"

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[48] *ECC Report 225, “Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services”, 21 October 2014, section 7.4.1, p.46*

[49] *Yanying Gu, Anthony Lo, Ignas Niemegeers, “A Survey of Indoor Positioning Systems for Wireless Personal Networks”, IEEE Communications Surveys & Tutorials, Vol. 11, No. 1*

[50] *EENA Operations Document, “Caller Location in Support of Emergency Services”, 19 November 2014, section 6.1.8, p. 14*

[51] *EENA NG112 Technical Committee Document, “Handset Derived Location for Emergency Calls”, 19 November 2014, Annex B.4, p. 11*

[52] *EENA Operations Document, “Caller Location in Support of Emergency Services”, 19 November 2014, section 6.1.8, p. 14*

The ECC report 225[53] confirms this position:

"*Due to its functioning premises (very short range, normal usage in correlation with IT devices) the fact that it is most useful in dense urban areas means that it provides a useful complement to methods which struggle in these locations (e.g. GNSS based methods in indoor environments).*"

Advantages of Wi-Fi positioning[54]

- Provides very high levels of accuracy, accuracy in the range of tens of meters, independent of the location type
- Location determination is independent of WIFI Operator or the WiFi technology
- Useful for indoor locations
- Location may be determined by the underlying operating system and/or specific applications
- Easy to deploy – already available on smartphones

Disadvantages of Wi-Fi positioning

- Accuracy is limited by low Wi-Fi access point availability and is significantly reduced in rural areas
- Relies on a database of Wi-Fi access point locations
- Changes in Wi-Fi access points locations are not immediately reflected in the location databases, resulting in possibilities for incorrect access point position stored in the database
- In most cases requires data connection from the MNO or a WiFi to query the online database
- The user may have switched off the use of Wi-Fi
- Requires download and use of a smartphone App, except for solutions that incorporate the location calculation in the OS or the manufacturer's software
- Available on smartphones or higher end feature phones

4.6 HYBRID POSITIONING METHODS

Hybrid positioning methods calculate the handset's location by using several of the previously described methods. The combination of different methods provides fall-back options when one method can not offer a location and result in an integrated positioning method taking into account the advantages and best features of all methods. In most cases, hybrid methods combine Cell ID, with GNSS and Wi-Fi positioning. Hybrid methods arise from the way mobile devices OS operate to

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[53] *ECC Report 225, "Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services", 21 October 2014, section 7.4.1, p. 46*

[54] *ECC Report 225, "Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services", 21 October 2014, section 7.6.1, Table 3, p. 50*

provide location information to smartphone Applications by using the OS's Application Programming Interfaces (API).

In the Android platform, an application does not have direct access to how the location is calculated and the methods that are used. An application will query the device's OS for a location estimation by an API call. The Android platform API guides describes the flow of obtaining user location[55]:

1. Start application.
2. Sometime later, start listening for updates from desired location providers.
3. Maintain a "current best estimate" of location by filtering out new, but less accurate fixes.
4. Stop listening for location updates.
5. Take advantage of the last best location estimate.

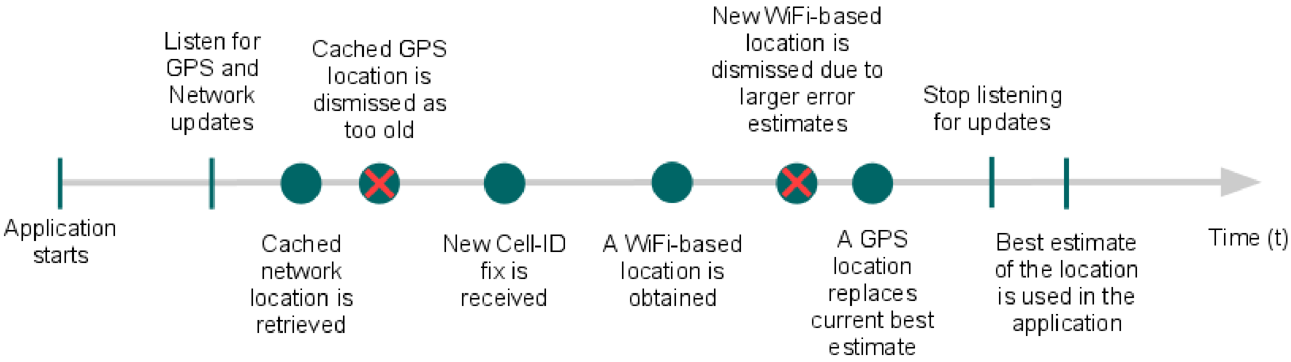

Figure 11. A timeline representing the window in which an application listens for location updates. Source: Android API Guides

Since hybrid positioning methods are combinations of other positioning methods, their advantages and disadvantages are determined by the individual methods. However, the complementarity of individual methods across different location types, provide an overall best case approach for all location types.

4.7 COMPARISON OF POSITIONING METHODS

This section aims to compare the previously described positioning methods in terms of availability, accuracy and TTFF. The ECC report 225[56] already provides a thorough comparison of methods across different conditions. The comparison provided in this chapter builds on the comparison of methods in the ECC report 225 and extends it with more information from the HELP112 consortium, when possible.

The following definitions are provided for clear interpretation of the comparison provided in Table 9.

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[55] *Android API Guides, "Location Strategies: Flow for obtaining user location", http://developer.android.com/guide/topics/location/strategies.html, accessed 4 March 2016*

[56] *ECC Report 225, "Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services", 21 October 2014, section 7.6.7, Table 5, p. 57*

Availability of the positioning method

As defined in the ECC report 225:

- AA - Always Available
- SA – Sometimes Available
- UN – Unavailable

Accuracy and precision of the positioning method

As defined in the ECC report 225 and also extended with data from the HELP112 consortium provided in metres when available:

- Very High
- High
- Medium High
- Medium
- Low Medium
- Low

TTFF

As defined in the ECC report 225:

- Shortest
- Shorter
- Short
- Medium

Location types

Three location types are defined based on the Average inter site distance of the mobile network:

- Urban
    - Average inter site distance = 500m
- Suburban
    - Average inter site distance = 1,500m
- Rural
    - Average inter site distance = 5,000m

The ECC report includes only rural and urban scenarios, but also introduces a dwellings density parameter, defined as low, medium and high. Table 5 of the ECC report shows that the dwellings density parameter affects the availability of the Wi-Fi positioning method. In the analysis of this deliverable, the dwellings density has been skipped and the availability of Wi-Fi varies as follows:

- Always available in urban locations
- Sometimes available in suburban locations
- Not available in rural locations

Sky visibility

The ECC report provides three values for the sky visibility parameter:

- Clear

- Partial
- No visibility

These values are also adopted in this deliverable and it is assumed that sky visibility is related to physical obstacles in the surrounding that may restrict the visibility of the sky. For example, partial visibility may be a location in an urban canyon, or an indoor location near a window. Similarly, no sky visibility may be an indoor location or an outdoor location with no sky visibility due to physical obstacles. Table 5 of the ECC report shows that GNNS availability depends on sky visibility. Specifically,

- GNNS is always available in clear sky
- GNNS is sometimes available with partial sky visibility
- GNNS is not available with no sky visibility

Following the ECC report, this deliverable takes into account that sky visibility affects the GNNS availability and does not affect the performance of the positioning method in terms of accuracy and TTFF. However, it should be noted that when for example the accuracy of a positioning method is quoted as medium in two different scenarios, the accuracy might vary between the scenarios and should not be considered identical if put on a finer scale.

Location type		Rural			Suburban			Urban			
Sky visibility		Clear	Partial	No	Clear	Partial	No	Clear	Partial	No	
Method / Network(s)											TTFF
Cell ID 2G, 3G, 4G	Availability	Always (GMLC only)									Shortest
	Precision[i]	5 km / ECC: Low			1.5 km / ECC: Low			500 m / ECC: Low-Med			
CITA (2G) & CITADV (4G): Cell ID with Timing Advance)	Availability	Always (requires GMLC, SMLC and E-SMLC)									Shorter
	Precision	2.5 km / ECC: Low-Med			800 m / ECC: Low-Med			250 m / ECC: Med			
CIRTT (3G): Cell ID with Round Trip Time	Availability	Always (requires GMLC and SAS)									Shorter
	Precision	2.5 km / ECC: Med			800 m / ECC: Med			250 m / ECC: Med-High			
CITARX (2G): Cell ID with Path loss and related measurements	Availability	Always (requires GMLC and SMLC)									Shorter
	Precision	1 km / ECC: Med			500 m / ECC: Med			200 m / ECC: Med-High			
Geo Multilateration (2G) RF Pattern Matching (RFPM)	Availability	Always (requires GMLC and SMLC)									Short
	Precision	700 - 800 m / ECC: Med			300 - 400 m / ECC: Med			150 - 200 m / ECC: Med-Hi			
O-TDOA (3G,4G): Observed Time Difference of Arrival	Availability	Always (requires GMLC, SAS and E-SMLC)									Short ECC: Med
	Precision	50 - 150 m / ECC: n/a[ii]			50 - 150 m / ECC: High			50 - 150 m / ECC: High			
A-GNSS[iii]	Availability	Always	Sometimes	n/a	Always	Sometimes	n/a	Always	Sometimes	n/a	Medium
	Precision	5 - 50 m / ECC: Very High		n/a	5 - 50 m / ECC: Very High		n/a	5 - 50 m / ECC: Very High		n/a	
Multi-constellation GNSS including Galileo	Availability	Always	Sometimes	n/a[iv]	Always	Sometimes	n/a	Always	Sometimes	n/a	Shorter than A-GNSS
	Precision[v]	< 5m		n/a	5 - 10m		n/a	5 - 10m		n/a	
Wi-Fi	Availability	Unavailable			Sometimes			Always			Shorter
	Precision	ECC: n/a			ECC: Medium			ECC: Very high			

Table 9: Comparison of positioning methods in terms of availability, precision and TTFF

The comparison of the methods in Table 9 indicates that no single solution works perfectly in all environments. Supporting more than one positioning method and utilising them according to their availability appears as the right approach that can satisfy the requirements for all location types. Additionally, fall-back methods should be considered when one or some methods are not available. A detailed analysis of the satisfaction of the HELP112 requirements by the different position methods follows in D1.3 Gap Analysis.

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[i] All accuracy estimates can be considered as "average" estimates, based on field experience and theoretical calculations.

[ii] The ECC report considers that O-TDOA is not available in rural areas. In the context of HELP112 it is assumed that the unavailability of O-TDOA in rural areas assumes there are no 4G cells available, perhaps because high data rates (furnished by 4G) are generally requested in city centres. Nonetheless, this assumption could have exceptions where for example it is needed to deliver high data rates in places where no other service provider may exist. Since there are no technological constraints restricting 4G cell availability in rural areas, the deliverable assumes their availability, as well as the integration of both GMLC and E-SMLC to the mobile network elements.

[iii] A-GNSS may be used as a network based or handset based method. Non-assisted GNSS has not been included in the comparison. It is expected to provide lower performance (TTFF and accuracy) than A-GNNS depending on the constellations used, but better than non GNSS NBL methods.

[iv] Multi-constellation GNSS under no clear sky conditions has been assumed not available, although Galileo is expected to allow enhanced indoor penetration and improved performances in urban canyons. See Fiammetta Diani, Justyna Redelkiewicz, European GNSS Agency, "Galileo value proposition for emergency caller location (E112), 7 May 2014, slide 16

[v] Precision estimates based on the accuracy estimates provided in Fiammetta Diani, Justyna Redelkiewicz, European GNSS Agency, "Galileo value proposition for emergency caller location (E112), 7 May 2014, slide 13

5. METHODS TO TRANSMIT THE LOCATION TO THE PSAP

Location information is transmitted to the PSAP following two stages. The mobile handset is at one end and the PSAP's CAD system at the other end. The first stage starts with the transmission of data related to location information, from the handset to a central point, server or database. In the second stage, the systems in the PSAP acquire the data from the central point and integrate it into the CAD system. Depending on the caller location solution studied, being a network based solution, AML or 112App, the location data transmitted from the handset and the role of the central point or location server differ. For example, the location data in the case of terminal based positioning techniques may be actual geographical coordinates or data related to measured signals in the case of a network based location solution. Similarly, the data may be transmitted to the central point using different communication channels, such as the signalling channel of the mobile network, SMS or IP. Various methods for caller location transmission can also be distinguished based on the end of the communication where the caller location data or its request originates – push and pull methods. The following three questions give an overview of the description that follows and analyse the transmission of caller location from the handset to the PSAP.

1. What data does the handset transmit?
   Depends on the positioning method and is covered in section 4. It should be noted that some methods may not require any additional data from the handset, e.g. location determined by Cell ID.
2. What channel is used to transmit the data?
   Signalling channel, voice channel, SMS, IP, described in sections 5.2, 5.3, and 5.4.
3. At which end does the location data transmission start?
   Push and pull methods described in section 5.1.

5.1 PULL AND PUSH METHODS

"Push" and "pull" methods define whether the PSAP receives or requests the caller location in the case of an emergency call. The "push" method is utilised when the location is sent to the PSAP from the handset or network and the "pull" method when the caller location is requested by the PSAP. The EEC report 225[57] defines "push" and "pull" methods:

"In the "Push" mechanism the location of the caller is received by the PSAP with all calls. Caller location information is provided to PSAPs handling 112 calls automatically with every 112 call and is available without delay for the 112 call handler, as soon as the call is received.

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[57] *ECC Report 225, "Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services", 21 October 2014, section 5.1, p. 26*

Using the "Pull" mechanism the PSAP operator asks for the location, if needed. Caller location is provided upon specific request by the 112 call handler, through an electronic request to a database, or, otherwise through a verbal request to the appropriate telecom operator. It is also possible that an automatic call for location information is generated by the information system of the PSAP."

The ETSI technical specification on location services describes[58] the information that may be provided to the client for either a "push" or a "pull" method:

Type of access	Information Items
Push	Current Dispatchable Location (if available) Current Geographic Location (if available) MSISDN SIP URL IMSI IMEI NA-ESRK NA-ESRD State of emergency call – unanswered, answered, released (note 1)
Pull	Dispatchable Location (note 2), either: Current civic location or Initial civic location at start of emergency call Geographic location (note 2), either: Current location or initial location at start of emergency call Both Dispatchable Location and geographic location (note 2), either: Current location or initial location at start of emergency call

Table 10: Information that may be provided to a client for "push" and "pull" methods. Source: ETSI 3GPP TS 22.071

NOTE 1: indication of call release means that any NA-ESRK will no longer identify the calling UE subscriber

NOTE 2: which type of location is required will be indicated by the LCS Client

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[58] *ETSI 3GPP TS 22.071 V14.1.0 (2015-09), section 6.2, Table 3, p. 27*

Considering that a PSAP may not always require accurate caller location for all emergency calls received, “pull” methods make better use of technical resources, because caller location is only estimated at the specific request of the PSAP. In some case, combinations of “push” and “pull” methods are also possible. For example, in the UK a “push” method is used for the stage 1 PSAP and a “pull” method for the stage 2 PSAP.

Table 11 summarises the current location solutions in EU member states.

Country	Type of Access
Austria	Pull
Belgium	Push
Bulgaria	Push
Croatia	Pull
Cyprus	Pull
Czech Republic	Pull
Denmark	Pull
Estonia	Pull
Finland	Pull
France	Pull
Germany	Push
Greece	Pull
Hungary	Push
Ireland	Push
Italy	Pull Location is provided centrally to the “CED Interforze” of the Ministry of Interior Location data is then forwarded where needed
Latvia	Push – 2 mobile network operators Pull – 2 mobile network operators
Lithuania	Push & Pull
Luxembourg	Pull
Malta	Pull
Netherlands	Pull

Country	Type of Access
Poland	Push
Portugal	Push
Romania	Push
Slovakia	Push. Pull in case of additional information
Slovenia	Push. Pull in case of additional information
Spain	Push – in 15 PSAPs (3 of them use it complementary to a Pull system, 2 further PSAPs are implementing the system, and 2 small PSAPs are currently evaluating different alternatives)
Sweden	Pull
United Kingdom	A combination of push from stage 1 and pull from stage 2

Table 11: Caller location solutions in Europe. Source: EENA Public Safety Answering Points in Europe[59]

From the 28 member states:

- 14 members states use only a "pull" method
- 9 use only a "push" method
- 5 use combinations of "push" and "pull" methods either between the different stages of PSAPs among the various MNOs or for additional information

5.2 VOICE CHANNEL

The voice channel over a mobile network is provided in circuit-switched networks when a dedicated channel is used for a voice call and is the channel allowing voice calls. A channel is considered to transmit a signal from one transmitter to a receiver and has a certain capacity for transmitting information, referred to as its bandwidth.

In 2G networks the voice channel is reserved only for voice calls, regardless if call is being carried out. As networks become IP based, they allow integration of data services with voice services and provide more efficient use of the available bandwidth. A key difference between CS and LTE

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[59] *EENA, "Public Safety Answering Points in Europe, 2015 edition", November 2015, Annex 1, p. 231*

networks is that in LTE, voice is just one of many potential media streams that can be communicated over the network[60].

In current caller location solutions, the only solution that uses the voice channel to transmit the information is eCall. When an eCall is received by the PSAP, an in-band modem is used to transmit the MSD from the vehicle to the PSAP.

Advantages of using the voice channel

- Wide availability across a wide range of location types
- Can be used by all handsets and does not depend on handset capabilities
- Calls to 112 are not charged

Disadvantages of using the voice channel

- Time needed to transmit the data compared to other methods
- The voice call must be interrupted to use it for sending data

5.3 SMS

112 SMS is currently offered to people with disabilities in some countries as an alternative to the 112 call. In other countries, it is available for all citizens. SMS is a technology that has proved its reliability over the years and has excellent geographic coverage. Despite its very popular use and wide availability, it should be noted that the delivery of a message is not always guaranteed. Sometimes messages are lost or delayed. Currently, there are no standards that describe how location could be automatically delivered with an SMS. AML is a solution that uses SMS for the transmission of the location and a suggested message format is available in the AML specification[61].

In a research report in 2008[62], the use of SMS as an emergency alert service was evaluated and has been reported as a technology prone to fraudulent use, because the source of the message can not be authenticated and the identity of a sender can be spoofed. In the context of HELP112, SMS is considered a communication channel from the handset to the PSAP. Therefore, the findings of this report do not directly affect SMS as a transmission method. However, security

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[60] *3GPP website, "Dispelling LTE Myths", http://www.3gpp.org/news-events/3gpp-news/1268-Dispelling-LTE-Myths, accessed 7 March 2016*

[61] *EENA Operations Document, "Advanced Mobile Location (AML) Specifications & Requirements", 2 March 2016, section 3.1, p. 7*

[62] *Cellular News website, "Report Says That SMS is Not Ideal for Emergency Communications", 16 Sep 2008, http://www.cellular-news.com/story/33684.php , accessed 8 March 2016*

considerations from unauthenticated sources should be considered, as already described in D1.1 Requirements Document.

SMS has also been considered as a method originating in GSM networks that are being replaced by newer generations with more capabilities offering richer communications. The 3GPP clarifies[63] that LTE will support a rich variety of messaging applications, including SMS:

"The solution is twofold, covering both the full IMS case and a transition solution for those networks that do not support IMS. SMS over IP was fully specified 3GPP Rel 7. It depends on IMS and it is intended to provide compatibility between the existing cellular legacy and the implementations with more elaborate messaging capabilities via SMS and IMS interworking. For environments without IMS a transition solution was specified. This is called SMS over SGs (previously called the misleading name: SMS over CS). It is a hybrid approach that allows the transmission of native SMS from CS infrastructure over the LTE radio network. SMS over SGs was specified as part of Rel 8. SMS over SGs provides SMS service for mobiles in LTE and since it requires also CS domain infrastructure for the SMS transmission, it is intended to be a transition solution."

Advantages of using SMS

- Offers the best geographic coverage, especially in remote areas
- Emergency SMS are usually not charged[64]
- Do not provide significant involvement or implementation from the MNOs
- Supported in all generation networks, including LTE
- Supported by all devices

Disadvantages of using SMS

- No standardised text format
- Security considerations should be taken into account

5.4 IP

Considering the increasing availability of LTE networks and the move of emergency services and PSAPs towards IP based communications, the transmission of caller location via IP appears as a future proof solution taking into account the latest standards in this domain. IP is currently used as the transmission methods in 112Apps. In the long term, IP offers significant advantages to

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[63] 3GPP website, "Dispelling LTE Myths", http://www.3gpp.org/news-events/3gpp-news/1268-Dispelling-LTE-Myths, accessed 7 March 2016

[64] Article 26 of the Universal Service Directive, 2002/22/EC & 2009/136/EC, which covers the "Single European emergency call number", does not explicitly state that emergency SMS should be free of charge, as it is stated for 112 calls. However, in practice, although MNOs may refuse zero rated emergency SMS, they provide it free of charge. Additionally, it is easier for MNOs to provide zero rated SMS than free data in the case of an emergency.

transmitting caller location, including non location related data that can be useful for emergency services. However, currently, the availability of the data connectivity in rural and remote areas is not widely supported. When the availability of LTE networks reaches a high geographical coverage, the advantages of IP can be used for transmitting caller location.

Standardisation groups as part of ETSI are working to create standards to support emergency call handling and location information transmitted by IP based communications, in LTE networks. The IP Multimedia Subsystem (IMS) is a core network framework for delivering IP multimedia services. It originates in 3GPP Release 5, finalised in 2002 and is based on IETF protocols such as SIP and SDP that are very mature. IMS is also being used in the rollout of IMS-based LTE networks. In release 7, an effort was made to optimize IMS and the supporting protocols to ensure that voice and other media were supported as efficiently as in circuit switched networks. In release 9, VoIP support for emergency calls (including location support) was specified. However, there are many difficulties encountered in rolling out IMS due to the need to shift the industry from CS services to a truly IP-based environment, i.e. service migration, policies, interoperability and deployment plan[65].

IMS will provide new opportunities in emergency call handling. The EENA report[66] describes:

"*When an IMS emergency call is sent to a PSAP, the device that sends it, as well as any application service provider in the path of the call, or access network provider through which the call originated may have information about the call, the caller or the location which the PSAP may be able to use. The IETF document "Additional Data Related to an Emergency Call*[67]*" describes data structures and a mechanism to convey such data to the PSAP. The mechanism uses a Uniform Resource Identifier (URI), which may point to either an external resource or an object in the body of the SIP message. The mechanism thus allows the data to be passed by reference (when the URI points to an external resource) or by value (when it points into the body of the message). This follows the tradition of prior emergency services standardization work where data can be conveyed by value within the call signalling (i.e., in body of the SIP message) and also by reference.*"

Advantages of using IP

- Future proof solution
- Standardisation activities look at the future of 112 calls including location information

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[65] *3GPP website, "Dispelling LTE Myths", http://www.3gpp.org/news-events/3gpp-news/1268-Dispelling-LTE-Myths, accessed 7 March 2016*

[66] *EENA NG112 Technical Committee Document, "Handset Derived Location for Emergency Calls", 15 April 2015, Annex C.4, p. 13*

[67] *Internet Engineering Task Force (IEFT), Additional Data Related to an Emergency Call, 15 December 2014, https://datatracker.ietf.org/doc/draft-ietf-ecrit-additional-data*

Disadvantages of using IP

- Use of the data channel is not free
- Handset and network support needed
- Low availability in rural and remote areas

6. METHODS TO PRESENT THE CALLER LOCATION IN THE PSAP

The next step after determining the caller location and transmitting it to the PSAP, is to make this information available to the PSAP staff. The caller location is valuable information to response staff with various roles, in order to conduct their work more efficiently and achieve an effective emergency response. The call taker is the first actor of the call handling process in need of the location information to confirm the location of the caller, but location information is also useful to dispatching teams and other staff in the PSAP.

PSAP staff can make use of the location information, when it is easily accessible to them and it is presentable in a meaningful way. Considering that the response time is a significant factor to achieve an effective response and that PSAPs make every effort to reduce this time, meaningful presentation of caller location becomes even more important.

Geographical locations in coordinates are not of great use to PSAP staff and they need to be converted to a location point on a map. The use of Geographical Information System (GIS) in emergency response is a critical system to ensure the quality high quality service[68]. PSAPs already receive location information estimated by Cell ID. When the location is displayed on the GIS, it converts the estimated latitude and longitude to a point displayed on the map and a radius around it to indicate the estimated accuracy in metres. Table 12 shows the availability of GIS in 112 PSAPs in all member states.

Country	GIS availability in 112 PSAPs
Austria	In some PSAPs
Belgium	In all PSAPs
Bulgaria	In all PSAPs
Croatia	In all PSAPs
Cyprus	Not available
Czech Republic	In all PSAPs
Denmark	In all PSAPs
Estonia	In all PSAPs
Finland	In all PSAPs
France	In some PSAPs

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[68] *EENA Operations Document, "112 PSAPs Technology", 10 March 2016, section 6, p. 17*

Country	GIS availability in 112 PSAPs
Germany	In some PSAPs
Greece	Not available
Hungary	In all PSAPs
Ireland	In some PSAPs
Italy	In all PSAPs
Latvia	In all PSAPs
Lithuania	In all PSAPs
Luxembourg	In all PSAPs
Malta	Not available
Netherlands	In some PSAPs
Poland	In all PSAPs
Portugal	In all PSAPs
Romania	In all PSAPs
Slovakia	In all PSAPs
Slovenia	In all PSAPs
Spain	In all PSAPs
Sweden	In all PSAPs
United Kingdom	In some PSAPs

Table 12: GIS availability in 112 PSAPs in the member states

From the 28 member states:

- 19 member states use GIS in all PSAPs
- 6 member states use GIS in some PSAPs
- 3 member states do not use GIS

The latitude and longitude of the location can be represented in different formats available. Conversion between formats can result in errors and loss of precision of the measurements. The ECC report 225[69] recommends keeping such conversions to a minimum and suggests that although

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[69] *ECC Report 225, "Establishing Criteria for the Accuracy and Reliability of the Caller Location Information in support of Emergency Services", 21 October 2014, section 5.2, p. 27*

the format can be agreed among the involved stakeholders, the World Geodetic System Datum 84[70] (WGS84) should be used. The WGS84 is the reference system for the GPS and is also used in eCall and AML.

In WGS84 the latitude and longitude are represented by a numeric value with decimal numbers. The number of decimal places available in value gives different precisions. Table 13 presents the resulting precision in relation to the decimal places provided in the value.

Decimals Places	Decimal degrees	Approximate Precision
0	1.0	111.3 km
1	0.1	11.1 km
2	0.01	1.1 km
3	0.001	0.1 km
4	0.0001	11.1 m
5	0.00001	1.1 m
6	0.000001	111.3 mm
7	0.0000001	11.1 mm
8	0.00000001	1.1 mm

Table 13: Resulting precision of different number of decimal places provided in decimal degrees according to WGS84. Source: Wikipedia[71]

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[70] *National Geospatial-Intelligence Agency (US) website, "WGS 84 Earth Gravitational Model", http://earth-info.nga.mil/GandG/wgs84/gravitymod/index.html, accessed 9 March 2016*

[71] *Wikipedia, "Decimal degrees", https://en.wikipedia.org/wiki/Decimal_degrees, accessed 9 March 2016*

7. EXISTING SOLUTIONS FOR CALLER LOCATION OF 112 CALLS

At the time of applying for the tender, the HELP112 project identified the four caller location solutions existing today, which are either available to be implemented or are already implemented in different EU member states. The four solutions are:

1. Network Based Location
2. Advanced Mobile Location
3. 112 Apps
4. eCall, including personal eCall and NG eCall

These solutions are different approaches explored by the different countries in order to achieve a more precise and accurate location information than the one estimated by Cell ID. A caller location solution can be mainly be considered as a combination of:

- a positioning method used to calculate the location information, as described in section 4
- a transmission method used to transmit the information to a PSAP or a central server that the PSAP can access, as described in section 5
- an activation method, i.e. the trigger used to initiate the location estimation and transmission

Considering these are the four possible technical alternatives existing today, it is important to consider, study and analyse these solutions in the state of the art and the comprehensive analysis of WP1.

The following sections describe the methods of estimating and transmitting the caller location, the advantages and disadvantages, and the actors involved in the deployment of each solution. An overview table of the solutions is provided in section 7.5 and their current status of deployment is described in section 7.6.

7.1 NETWORK BASED LOCATION

7.1.1 Purpose

This section describes the architecture and processes needed for the provision of an integrated node or nodes in the mobile network (called GMLC/SMLC/SAS/E-SMLC) to support the specific range of messages and functions in-line with the 3GPP standardised network infrastructure for Location Services.

7.1.2 Symbols

For the purposes of this document the following symbols apply:

Symbol	Definition
Gb	Interface between SGSN and BSS
Gs	Interface between MSC and SGSN

Iupc	Interface between RNC and SAS (RNC interface)
Lb	Interface between Serving MLC and BSC (BSC interface)
Lc	Interface between gateway MLC and gsmSCF (CAMEL interface)
Le	Interface between External User and MLC (external interface)
Lh	Interface between Gateway MLC and HLR (HLR interface)
Lg	Interface between Gateway MLC and VMSC (gateway MLC interface)
Lp	Interface between SMLC and peer SMLC (peer interface)
Ls	Interface between Serving MLC and VMSC (serving MLC interface)
Um	Air Interface to an LMU (measurement interface)
Lup	User plane interface supporting the user plane location protocol

Table 14: List of symbols used in Network Based Location figures

7.1.3 References for LCS Standards

1. 3GPP TS 071 - Location Services (LCS) Functional description Stage 2
2. 3GPP TS 23 271 - Functional stage 2 description of Location Services (LCS)
3. 3GPP TS 43 059 - Functional stage 2 description of Location Services (LCS) in GERAN
4. 3GPP TS 25 035 - Stage 2 functional specification of User Equipment (UE) Positioning in UTRAN
5. 3GPP TS 101 724 - Functional stage 2 description of Location Services (LCS)
6. 3GPP TS 18 071 - Base Station System (SMLC-BSS) interface, Layer 3 specification
7. 3GPP TS 48 071 - SMLC-BSS Interface
8. 3GPP TS 49.031 – BSSAP LCS Extension (BSSAP-LE)
9. 3GPP TS 23.032 - Universal Geographical Area Description (GAD) (Release 7)
10. 3GPP TS 23.078 – Lc interface (CAMEL)
11. 3GPP TS 25.453 – UTRAN Iupc interface Positioning Calculation Application Part (PCAP)
12. OMA SUPL 1.0 specification http://www.openmobilealliance.org
13. 3GPP TS 44.031 – Radio Resource LCS protocol (RRLP)
14. 3GPP TS 29.171: "LCS Application Protocol (LCS-AP) between MME and E-SMLC; SLs Interface".
15. 3GPP TS 29.173: "Location Services (LCS); Diameter-based SLh interface for Control Plane LCS".

7.1.4 Overview

Location Services (LCS) cover services using the positional (geographical) location of mobile user's equipment (UE) to offer a range of value added services.

The location of a user's mobile is defined in terms of latitude and longitude coordinates. The accuracy and precision depend on the particular technique used to locate the mobile. Several mobile industry variants are currently deployed. The method for 'requesting' a user's mobile location and the resultant network generated messages are standardised regardless of the location technique in use.

7.1.5 Location Infrastructure

The ability of a mobile network to establish the location of a user mobile is essential to ensure incoming calls are 'directed' to the appropriate cluster or group of cells. Such clusters or groups are defined/known as Location Areas. To maintain this situation mobiles continually assess and measure the radio parameters from surrounding/neighbouring cells and detect when moving from one cell area Location Area Code (LAC) to another.

Using this information it is possible to 'triangulate' the geographic position of a user mobile. This information may include the serving cell (Cell ID), relative signal strengths of neighbouring cells and timing advance settings. To externalise this information and control the management of authorised requests, from PSAP requirement, requires the network provision of two additional nodes named the Gateway Mobile Location Centre (GMLC) and the Serving Mobile Location Centre (SMLC) – the variants being Standalone Mobile Location Centre (SAS) for 3G and Evolved SMLC for LTE. This is illustrated in the following figure.

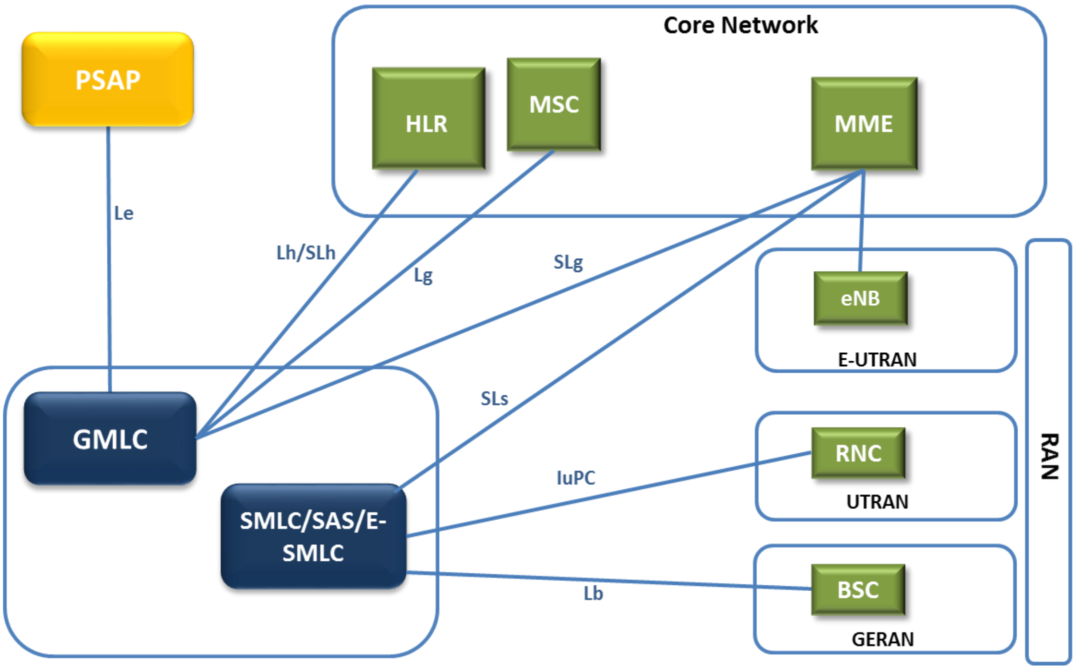

Figure 12 LCS 3GPP Architecture

7.1.6 How the Mobile Location is Calculated Replying PSAP Request?

The GMLC provides the interface to the LCS client (i.e. PSAP) which may be positioned external to the network. The GMLC receives individual requests to locate and report back the geographic position of a user mobile.

The GMLC must first determine which Serving Mobile Switching Centre (MSC) is managing the UE at the time the LCS request is made. To do this it first identifies the MSC involved by making a request to the HLR. The HLR returns this information and a message is sent to the appropriate BSS via the MSC. The BSS determines the serving Cell ID and if available the timing and signal strengths from this and neighbouring cells.

This combined information is routed to the SMLC/SAS where the calculation of geographic position estimation is carried out. The result is passed back to the MSC via the radio sub system and then to the GMLC for delivery to the LCS client (according to the 3GPP standards, there is no direct connection between the SMLC/SAS and the GMLC – the location is always reported back to the MSC that has initiated the location request).

7.1.7 Interfaces

7.1.7.1 Application interface (Le) - PSAP

The interface provided complies with OMA MLP V3.2 and V3.1. Priority levels are handled through the optional selection of a priority level within the request and feeding appropriate prioritised queues.

All the following messages flows are supported as per OMA:

- SLIS (Standard Location Immediate Service)
  This is a standard query service for requesting the location of one or more Mobile Subscribers (default max 600). It is used when a location response is required immediately (within 10 seconds) or the request may be served by several asynchronous location responses (until a pre-determined timeout limit is reached – default 30 seconds)

- ELIS (Emergency Immediate Service)
  This service is used for querying the location of a mobile subscriber that has made an emergency call to an emergency call centre or similar and the centre requests the mobile location. The response to this service is required immediately (within a set time - default 10 seconds).

- TLRS (triggered location reporting service)
  A service which is used when the LCS client wants the position of single or several MSs to be tracked. Reponses will be sent periodically from Location Server or be sent when the MS take actions (like a change of area).

7.1.7.2 MSC/HLR interfaces (Lg/Lh)

- GMLC can interface with any HLR/MSC/SGSN that supports 3GPP 29.002.

- According to the 3GPP LCS architecture, the interface between GMLC and HLR is called the Lh interface, and the interface between GMLC and MSC/SGSN is the Lg interface.
- GMLC uses the Lh interface to obtain routing information of a target terminal. It uses the Lg interface to request the positioning information of a target terminal from the radio network via the core network.

7.1.7.3 BSC interface (Lb) – 2G

SMLC implementation is based on 3GPP TS 49.031 for the Lb interface with BSSMAP-LE PERFORM LOCATION service primarily over SS7-SCCP protocol.

7.1.7.4 RNC interface (IuPC) – 3G

SAS implementation is based on 3GPP TS 25.453.SAS supports both SAS centric and RNC centric location service. It uses PCAP Position Initiation, Position Activation and Perform Location services over IUPC interface.

7.1.7.5 MME interface (SLg,SLs) – 4G

The GMLC supports SLg interface towards MME as per 3GPP TS 29.173, with PROVIDE-SUBSCRIBER-LOCATION as the primary service using ELP protocol.

The E-SMLC supports SLs interface towards MME as per 3GPP TS 29.171, with LOCATION-SERVICE-REQUEST as the primary service using LCS-AP protocol. E-SMLC supports LPP and LPPa messages.

7.1.7.6 HSS interface (SLh)

The GMLC supports SLh interface towards HSS as per 3GPP TS 29.173, to query the routing information of the target to be located. It uses LCS-ROUTING-INFO service.

The table here below presents more details about the interfaces supported by each LBS Node:

LBS Node	Interface	For (other node)	Protocol	Standard reference
GMLC	Le	LCS client	MLP3.1, 3.2	OMA
GMLC	Lh	HLR	MAP	3GPP TS 23.271 3GPP TS 29.002
GMLC	Lg	MSC	MAP	3GPP TS 23.271 3GPP TS 29.002
GMLC	Lc	gsmSCF	CAMEL	3GPP TS 23.078
GMLC	SLh	HSS	Diameter	3GPP TS 29.173
GMLC	SLg	MME	ELP	3GPP TS 29.172

SMLC	Lb	BSC	BSSMAP-LE	3GPP TS 48.071 3GPP TS 49.031
SAS	Iupc (UTRAN)	RNC	PCAP	3GPP TS 25.453
E-SMLC	SLs	MME	LCSAP	3GPP TS 29.171

Table 15 Interfaces and Protocols

7.1.8 Gateway Mobile Location Centre

The GMLC connects to HLR, MSC/SGSN through the Lh and Lg interfaces respectively. SGSN support is provided for UE with packet switch (PS) connection.

7.1.9 Serving Mobile Location Center

NB This node is required for all network based location techniques other than simple Cell ID.

7.1.9.1 SMLC

BSS based SMLC supporting the Lb interface and compatible with multiple BSC vendors.

The SMLC serves multiple BSCs.

The SMLC 'controls' a number of BSCs for the purpose of obtaining radio interface measurements to assist in locating the target UE. Signalling between the BSS based SMLC is transferred via the BSC using the Lb interface.

The location calculator is located within the SMLC.

Accuracy depends on network density, the network environment, the available network data, and to some extent the handsets themselves.

7.1.9.2 SAS (Standalone SMLC for 3G)

The Standalone SMLC operates in a similar way to the SMLC but towards the RNC through the Iupc interface. The positioning methods supported by the SAS are Cell, CIRTT (Round Trip Time) and Multilateration.

The underlying protocol used is PCAP and it is defined in 3GPP TS 25.453. Accuracy is higher than in 2G and the same concepts apply. It should be noted that the accuracy achievable will be related to the algorithms used, which in turn is dependent on the available network data.

7.1.9.3 Location calculator

The location calculator is responsible for producing an estimate of the position of mobiles based on the radio information provided by the BSC through the Lb interface, by the RNC through the Iupc interface (or alternatively through the MSC in a specific case).

7.1.9.4 Cell Tower Updater

The Cell Tower Updater is usually triggered on a regular basis, typically every night, to update the database with new or modified cells.

The Database maintains the position of all towers and performs pre-calculations for all location methods.

7.1.10 Actors involved

In the deployment of a Network Based Solution the following actors are involved:

- Mobile Network Operator
  Manage and coordinate the integration of location platform with the network elements.
- Network vendor
  To enable the required 3G standard interfaces (i.e. Lg, Lh, Lb) on their MSC, HLR and BSC respectively.
- Location supplier
  Integrating their location platform to the mobile network.

7.2 ADVANCED MOBILE LOCATION

Advanced Mobile Location[72] (AML) has been operating in the UK since July 2014. BT in the UK partnered with the MNOs EE, O2, Three and Vodafone, and the handset manufacturers HTC, Alcatel, Sony Mobile and Samsung to implement and deploy the AML solution. The objective of the AML is to produce a simple, cost effective solution to the mobile location problem that makes use of the built-in location capabilities of modern handsets. Once the mobile handset knows its location it is sent to the PSAPs using a simple, already available, Short Message Service (SMS) based protocol, which gives up to 160 characters of data. An ETSI Technical Report[73] published in March 2016 provides a reference on AML for administrations, mobile networks and handset manufacturers.

7.2.1 Positioning method

AML uses GNSS and Wi-Fi positioning to compensate the lack of accuracy by the existing implementation of caller location estimated by Cell ID. As soon as the emergency call is initiated the handset switches on GNSS and Wi-Fi, if not already activated and subject to a battery check. The battery check is up to the handset manufacturers/OS provider to decide when the AML functionality should not be triggered because of the battery level. The battery check should restrict the AML functionality to allow for a short, 5 minute, voice call to be placed.

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[72] *This section has been based on the specifications and requirements of AML as described in:*
EENA Operations Document, "Advanced Mobile Location (AML) Specifications & Requirements", 2 March 2016

[73] *ETSI Technical Report, "Advanced Mobile Location for emergency calls", ETSI TR 103 393 V1.1.1 (2016-03)*

In the AML, the handset immediately attempts to determine the location via all methods in parallel, so as not to delay transmission of location after a specific time interval, defined as the T1 timeout. The T1 timeout is the maximum time between the emergency call being initiated and the location SMS is sent. The AML specification suggests that T1 should be configurable with an "over the air" update. In the UK, the T1 timeout is set to 20 seconds.

The process to calculate the location is defined by the following rules and is depicted in the timeline depicted in Figure 13.

- If GNSS data becomes available before the T1 timeout, then that data is sent without waiting for the timeout.
- If at T1 seconds no GNSS data is available, but location is available based on Wifi SSIDs or MAC addresses of nearby access points, then the Wifi location is sent.
- If no Wifi based location is available then the cell ID based location data is sent.
- If GNSS or Wifi was switched on when the emergency call was initiated, then it should be then switched off as soon as it is no longer needed.
- If it's not been possible to get a location from any method then an SMS is sent indicating that all positioning methods have failed.

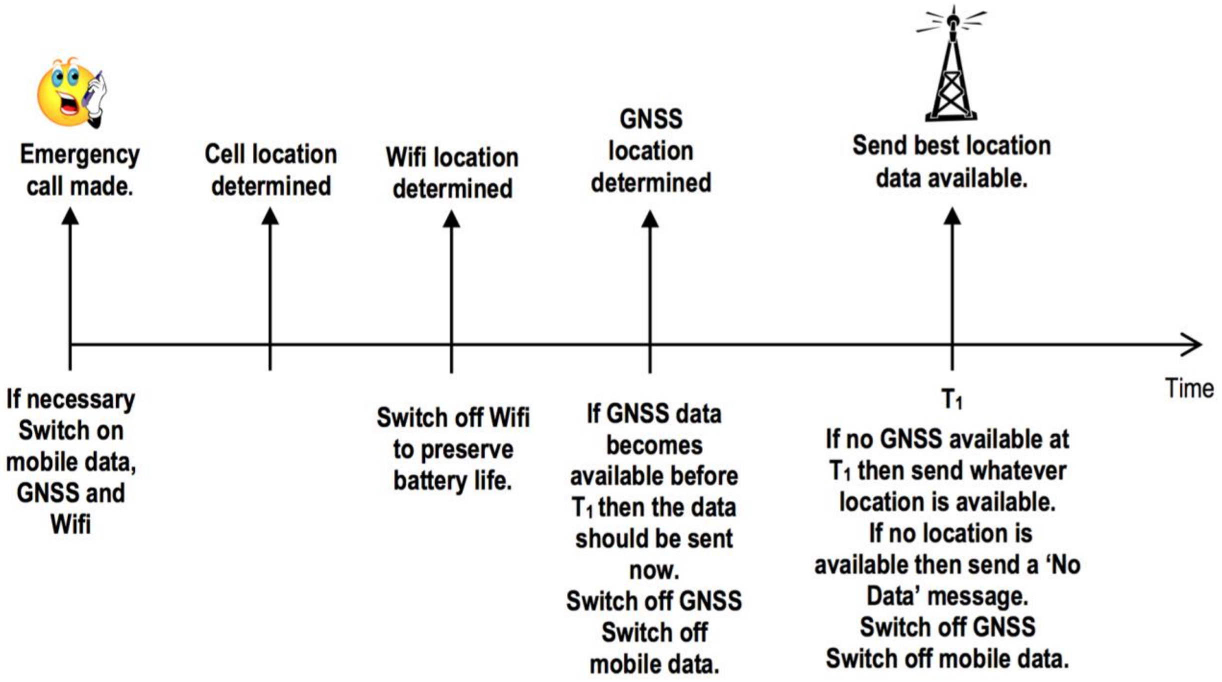


Figure 13: AML timeline and process to estimate the caller location. Source: BT

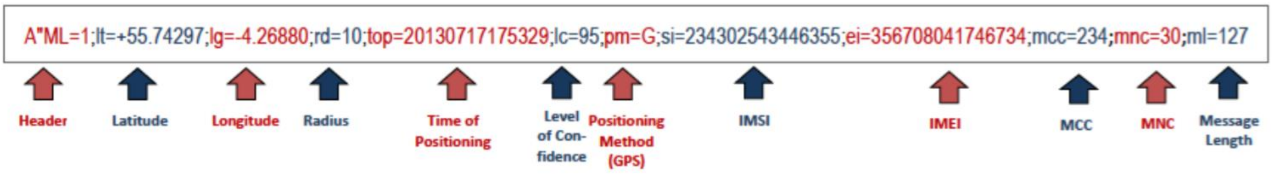
7.2.2 Transmission method

When the location is determined the AML SMS is generated. It consists of a series of message attributes separated by a semi colon ";" character without spaces. Each attribute consists of a name/value pair where names and values are separated by an equals "=" character again without any spaces.

A header record must always appear at the start of the SMS and it used to route the SMS to the AML system. A message length attribute must always be the last attribute in the SMS message. More important attributes (latitude, longitude, radius) will appear at the beginning of the SMS with less important towards the end. The detailed description of each attribute can be found in the AML specification[74].

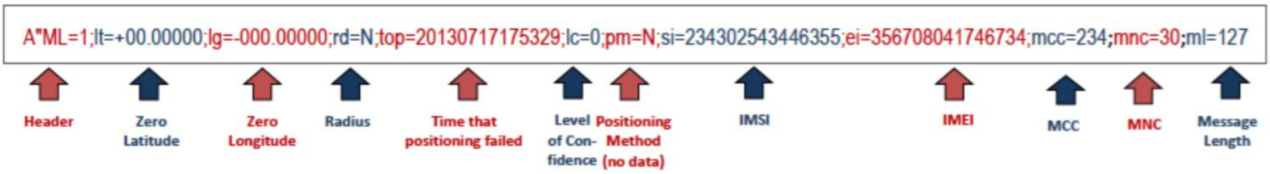
The AML specification suggests that two types of SMS may be used to provide the AML location information: "regular SMS" and "data SMS". "Data SMS" is a particular subset of the SMS standard and it is important to note that this is not an SMS message sent through a data connection. It is an SMS, which contains a particular type of binary data format as a payload, and is addressed to a particular port on the receiving end. Which type of SMS message is used may depend on the options open to handset manufacturers or OS providers to suppress a record of sent AML location message on the handset.

Figure 14 and Figure 15 provide examples of the SMS message used in the AML solution, when a location has been calculated and when the handset was unable to determine a location.



A"ML=1;lt=+55.74297;lg=-4.26880;rd=10;top=20130717175329;lc=95;pm=G;si=234302543446355;ei=356708041746734;mcc=234;mnc=30;ml=127

Figure 14: Example AML SMS with location data



A"ML=1;lt=+00.00000;lg=-000.00000;rd=N;top=20130717175329;lc=0;pm=N;si=234302543446355;ei=356708041746734;mcc=234;mnc=30;ml=127

Figure 15: Example AML SMS without location data

7.2.3 Actors involved

The following actors are involved in the deployment of an AML solution:

- Handset Manufacturer / OS provider
    - Implement the AML functionality
    - AML SMS message should be sent only in AML ready countries based on MCC/MNC to a short SMS number determined by MCC
- Public Authority

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[74] *EENA Operations Document, "Advanced Mobile Location (AML) Specifications & Requirements", 2 March 2016, section 3.2, p. 9*

    - Be able to receive the AML SMSs (regular and “Data SMSs”) and display the location in their CAD systems
    - Ask MNOs to contact handset manufacturers so that they deploy AML
    - Decide guidance for call takers for comparing Cell ID and AML locations
- MNO
    - Contact handset manufacturers so that they deploy AML
    - Transmit the SMS free of charge
    - Test AML with handset manufacturers and PSAPs
    - Ensure with network equipment providers that the SMS can be sent during the emergency call (change this switch parameter if needed)

7.2.4 Advantages and disadvantages

The use of AML in the UK has led to improved accuracy levels as handset technology can provide a location precision as good as 5 metres outdoors and averaging to within circular areas of approximately 25m radius for indoor locations. This is a significant improvement on the existing cell coverage provided by mobile networks, of which the average, across the UK, is about 1.75km radius. AML doesn't ignore the Cell-ID information that already existed but rather supplements it with either GNSS information or Wifi information taken from the handset.

In February 2016, BT was handling approximately 4000 emergency calls per week using AML. From 4000 handset locations each week, approximately 40% use A-GNSS/GNSS location information, 34% use Wi-Fi location information, and 8% Cell location. For 18% of handset messages received there is no additional caller location information available from the handset. 91% of the handset locations are accepted after comparison with network location (to eliminate any cases where handset is unable to provide a reliable current location, for example if WiFi data has not been updated). In 87% of accepted handset locations, location accuracy is given as approximately within 50 meters. 90% of locations arrive within 30 seconds of the network location being provided.

The advantages and disadvantages of AML as a caller location solutions are:

Advantages

- Use of a hybrid positioning method provides the highest level of accuracy and availability
- Takes advantage of positioning methods already available on handsets
- Simple to develop and be launched rapidly - No significant investment is needed by the mobile networks or handset providers
- Easy to deploy in countries where there is already a text to 112 service
- Does not require a data connection - sending an SMS is possible in most location types and it has wider availability that the data connection
- Transmission of location is automatically triggered without the need for manual intervention by the user

- AML can switch on GNSS services and Wi-Fi connectivity on the handset, even if it is switched off by the user to achieve a location with good accuracy

Disadvantages

- Not all mobile devices are supported
- Requires implementation by handset manufacturers or OS vendors
- International roaming is not yet supported

7.2.5 AML version 2

In the latest EENA member's workshop[75] on 20 October 2015, the result of the AML v2 workshop was a draft of the future requirements of AML and a possible standard. The main requirements reported from the workshop are:

- Roaming scenarios
  - To be solved between emergency services if possible
  - Service to be activated on handsets and MNOs when roaming
  - Ensure SMS is free of charge - look into having one EU number e.g. 112, 116 range?
- Z axis positioning
  - Could be useful if it can be translated into valuable operational information
- Inserting the Cell ID
  - To be decided at country level so that the SMS is routed to the good PSAP
- Frequency of location
  - First location data sent after 20 seconds maximum
  - Let the phone send the data; it should not be triggered by the PSAP
  - Several location data sent during the call (according to battery level)
  - If location data not available after 20 seconds, phone to trigger it again
  - What if two versions of AML are enabled on the phone, from the OS provider and the handset provider?
  - Only one SMS should be sent
  - OS and handset manufacturer to solve the issue together
- Matching AML data with network data
  - To be decided at country level so that the SMS is routed to the good PSAP
- AML Service and Internet data

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[75] *EENA report, "EENA Members Workshop & Meet your MEP event 2015", http://www.eena.org/download.asp?item_id=147*

- NG112 and Pan-European Mobile Emergency App (PEMEA) architecture work to be followed

7.3 112 APPS

There are many 112 Apps on the market, made by emergency services, PSAPs, and commercial companies. The deployment of 112 Apps has initiated from the need of emergency services to receive accurate caller location and the wide availability of mobile handsets with the capability to provide it. Matching the need for accurate location with the capabilities of smartphones was reinforced due to the barriers of implementing more accurate network based location solutions. In a COCOM questionnaire in 2011, 19 countries believed that a smartphone App is a valuable supplement for location information, proving the attractiveness for their use.

The 112 Apps provide a "speed dial" button to 112, while the caller location is calculated by the handset and sent to the PSAP. In addition to providing accurate caller location, apps are a powerful tool for bi-directional communication (A2C) and (C2A) and use additional features offered by smartphones, such as video calls and additional health information.

While accurate caller location can be resolved with emergency calling apps, they do not come without limitations:

- Apps operate only within a local or national territory
- Citizens have to be aware of the app and download it
- Citizens have to remember to use the app when in an emergency situation

The first limitation has been one the driving factors of EENA's 112 Apps Strategy[76], for the "Pan-European Mobile Emergency Application"[77] (PEMEA), in addition to other factors such as roaming calls becoming a critical issue in achieving a Pan European app. PEMEA does not suggest one specific app for all of Europe, but defines the architecture, the requirements and deployment guidelines and a certification program that aims to allow multiple apps from different or the same regions operating effectively everywhere across Europe. PEMEA can be thought of as a framework for enabling multiple pan-European emergency applications, avoiding the risk of multiple applications that are not compatible and not tested to work in other EU countries, while callers will be able to use the service in their own language while being abroad. Additionally, a pan-European standardised way to access 112 through Apps would also put PSAPs more in control and avoid them having to rely on propriety technology.

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[76] *EENA Operations Document, "112 Apps Strategy - Pan European Mobile Emergency Apps", 17 March 2015*

[77] *EENA NG112 Technical Committee Document, "Pan-European Mobile Emergency Application (PEMEA) Requirements and Functional Architecture", 2 December 2015*

7.3.1 Positioning method

112 Apps use the positioning methods available on the handset. Most smartphones currently offer a variety of positioning methods, including GNSS, WiFi and hybrid. Since smartphone apps do not have direct access to the handset hardware to estimate the location, the app requests the location from the operating system, when an emergency call is placed by the app. It should be noted that apps do not have the permission to automatically switch on or off services of the handset, such as location services. Apps can ask the user's permission to enable the needed services, a very useful practice, which is though inappropriate in the case of and emergency app. The operating system respects respecting the user preferences regarding location services, provides a calculated location with the enabled methods.

7.3.2 Transmission method

Smartphones can use a variety of methods to transmit the location, with two methods being the most popular: IP and SMS. When an emergency call is placed, the location estimate is usually sent on the smartphone's data channel. If data connectivity is not available, some apps will send the location by an SMS. The selection of the transmission channel depends on how the app has been implemented. The selection of the data channel with the SMS being a fall-back methods, ensures the location can be transmitted in wide range of location types.

7.3.3 Actors involved

112 Apps is a caller location solution with only few actors involved in their deployment, the public authority providing the app to the public and the app provider:

- Public Authority
  - Be able to receive the information from the app and display the location and other information in their CAD systems
  - Promote the download and use of the app
- App providers
  - Implement the app and ensure it complies with standards and the PEMEA architecture

7.3.4 Advantages and disadvantages

This section describes the advantages and disadvantages of 112 Apps.

Advantages

- Accurate caller location by using GNSS, Wi-Fi and hybrid methods
- Availability in many location types
- Takes advantage of positioning methods already available on handsets
- Possible to use SMS when the data is not available, depending on implementation
- Handset-based additional data can be made available to emergency services

Disadvantages

- Citizens need to download the app and remember to use it in an emergency situation
- User can switch off location services and result in reduced accuracy levels
- Apps work within their local or national boundaries
- Not all mobile devices are supported
- Many false calls are received

7.4 ECALL

eCall[78] aims to bring rapid assistance to motorists involved in a collision anywhere in the European Union. A vehicle equipped with eCall will establish a 112 voice call to the nearest PSAP in case of a traffic incident. eCall can be triggered manually by vehicle passengers or automatically via activation of in-vehicle sensors when a serious road accident occurs. The manual activation of eCall is useful to alert emergency services about traffic incidents that do not meet the threshold of the automated notification, or a vehicle occupant with a medical emergency. A voice channel is established during the call between the vehicle passengers and the emergency service receiving the eCall. Even if no passenger is able to speak, a 'Minimum Set of Data' (MSD) is sent to the PSAP, including the location information and other related data such as the triggering mode (automatic or manual), the vehicle identification number, a timestamp, as well as current and previous positions[79].

7.4.1 Positioning method

eCall is using non assisted and non augmented GNSS as a positioning method in the in-vehicle equipment (IVE). The current implementation of eCall calculates the position estimate by GPS. Future eCall implementations, equipped with the appropriate chips, will also use GLONASS, Galileo and EGNOS.

A theoretical and practical study, conducted in a real situation on the combination of motorways and regional roads in northern Croatia, assessed the performance of non assisted GPS for eCall. The findings of the study proved that the sole utilisation of a single position estimation method result in lack of performance and may cause potentially dangerous effects on emergency operations and restoration of the traffic flow after the accident. Performance degradation is result from insufficient satellite signal availability and positioning error sources.

Assisted and augmented GNNS methods are suggested for mitigation of the performance lack. For example, the GPS positioning performance can be enhanced by utilisation of EGNOS. EGNOS enhances the accuracy by providing three additional GPS-like signals, thus improving availability of satellite signals and quality of position estimation process. However, utilisation of EGNOS in eCall requires the in-vehicle systems (IVS) to be equipped with EGNOS enabled GPS receivers.

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[78] *EENA Operations Document, "eCall", 13 August 2014*

[79] *EENA, "eCall Fact Sheet: Everything that you wanted to ask, but did not know how", 2015*

Improvements in the TTFF are also expected by the use of A-GNSS. Assisted data can be provided to the IVE by the mobile networks and are expected to reduce the TTFF[80,81].

7.4.2 Transmission method

eCall uses a data and voice link over the same channel to send data and to establish the voice call between the passengers of the vehicle and emergency services. The data link is realised by an in-band modem, which has been specifically designed and standardised for eCall. This approach guarantees an EU-wide availability of free eCall data transmission through established 112 voice call mechanisms. In the case where the data is not sent or received for any reason, the eCall continues as a normal 112 emergency call. The priority given to normal 112 calls in the mobile network also applies to the eCall data transmission. This maximises the coverage and availability of the eCall service.

A Minimum Set of Data (MSD) has been defined and it is standardised by the European Committee for Standardisation (CEN), document number EN 15722[82]. The EENA operations document[83] on eCall states that the MSD includes the following information:

- Message identifier: MSD format version (later versions to be backwards compatible with existing versions).
- Activation: whether the eCall has been manually or automatically generated
- Call type: whether the eCall is real emergency or test call
- Vehicle type: passenger Vehicle, buses and coaches, light commercial vehicles, heavy duty vehicles, motorcycles
- Vehicle identification number (VIN)
- Vehicle propulsion storage type: This is important particularly relating to fire risk and electrical power source issues (e.g. Gasoline tank, Diesel tank, Compressed natural gas (CNG), etc.)
- Time stamp: Timestamp of incident event
- Vehicle location: determined by the on-board system at the time of message generation. It is the last known vehicle's position (latitude and longitude)
- Confidence in position: this bit is to be set to "Low confidence in position" if the position is not within the limits of +/-150m with 95% confidence
- Direction: helpful to determine the carriageway vehicle was using at the moment of the incident
- Recent vehicle location n (Optional): vehicle's position in (n-1) and (n-2)

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[80] *Renato Filjar, Gérard Segarra, Ilinca Vanneste, Pavao Britvic, Krešimir Vidovic, "Satellite positioning for eCall: an assessment of GPS performance", http://www.heero-pilot.eu/ressource/static/files/filjar_segarra_vanneste_britvic_vidovic_rev_b.pdf*

[81] *Renato Filjar, Kresimir Vidovic, Pavao Britvic, "Scenarios of critical GPS positioning performance for eCall", http://www.heero-pilot.eu/ressource/static/files/filjar_vidovic_britvic_confpaper.pdf*

[82] *CEN, EN 15722, "Intelligent transport systems - eSafety - eCall Minimum set of data", 1 April 2015*

[83] *EENA Operations Document, "eCall", 13 August 2014, section 6, p. 9*

- Number of passengers (Optional): number of fastened seatbelts
- Optional additional data (Optional): in some cases, optional data may be available in the MSD (at the vehicle manufacturer discretion). This data incorporate a tag for the identification in the beginning of the optional data (type and structure identification). This data will be registered and maintained. PSAP will have free access such data registry data.

7.4.3 Actors involved

eCall involves a number of different stakeholders all with separate responsibilities and tasks[84]. The main actors are:

- In-vehicle equipment provider(s)
    - Equip vehicles with eCall following the relevant EU Regulations
    - Ensure the functionality of the in-vehicle system
    - Comply with EU Regulations on data protection and free consumer choice
- Mobile network operators (MNO)
    - Implement the eCall flag
    - Treat eCalls as 112 emergency calls (free of charge, priority, national roaming, etc.)
    - Provide the right routing based on eCall flag following the instructions of the National Authorities
    - Providing SIM cards for the IVE (based on commercial agreements)
- Telecommunication National Regulators
    - Checking that all legal requirements are complied, for example, Telecoms operator to provide the eCall flag
- Emergency services, PSAPs and their software and hardware providers
    - Infrastructure set-up (e.g. integrate eCall into the PSAP systems)
    - Verify that eCall information is correctly received
    - Training of operational and technical staff
    - Establishment of operational protocols
- Competent Authorities of Emergency Services
    - Make sure that emergency services have the necessary means (including budget) to adapt their systems to eCall
    - Solve multi-languages cases

7.4.4 Advantages and disadvantages

The main advantage of eCall is its wide deployment currently undergoing in the EU member states, due to the support of the legislation. Use of the voice channel as a transmission method imposes the major advantages and disadvantages of eCall:

Advantages

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[84] *EENA Operations Document, "eCall", 13 August 2014, section 12, p. 33*

- Highest coverage and availability in all location types
- Supported by legislation and standardisation
- It's a pan-European approach and works for roaming users
- Has the same prioritisation as a 112 call
- Minor changes required in the mobile networks (eCall flag and PSAP routing tables)

Disadvantages

- Low position estimation accuracy due to lack of A-GNSS and augmented GNSS
- Takes longer than other methods to transmit the data
- The voice call is interrupted to transmit the data
- A lot of fake calls filtering of false emergency calls (primarily for manual eCalls) will have to be done directly at the PSAP
- Based on old technology

7.4.5 NG eCall

The PSAP operator may at any time request that a new MSD is sent (e.g. data appears corrupted or inconsistent, or the PSAP operator believes that the data may have changed).

The Next Generation (NG) eCall is already being discussed[85]. NG eCall focuses on the transmission of data and voice to the PSAP, by taking into account the new technical capabilities that are being introduced by the evolution of mobile networks. However, the shift from circuit switched technologies to LTE networks will be evolutionary. Until its full deployment, large parts of the existing network infrastructure will be reused and since eCall is based on a CS emergency call, it will be supported in mobile networks for a quite some time.

In LTE networks there are no circuit-switched technologies and therefore no CS emergency call and eCall. Voice over LTE (VoLTE) packet switched technology will be implemented instead. VoLTE is founded on IMS specification. The IP Multimedia Subsystem (IMS) is an architectural framework for delivering Internet Protocol (IP) multimedia services in all-IP networks. Many of the necessary features to support eCall in the IP environment already exist in IMS standards for emergency services, which are already implemented and deployed. Only small additions are necessary to specify IMS eCall based on existing standards.

ETSI Mobile Standard Group (MSG) has prepared a technical report[86] on future eCall and migration challenges, as well as a proposal for relevant LTE standards. The main idea is to include the eCall Flag in the IMS signalling by the IVE. Routing of an eCall to a PSAP in the IMS packet switched domain should be performed using newly specified Unified Resource Names (URNs). Similarly,

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[85] *This section is based on the following two documents*

EENA Operations Document, "eCall", 13 August 2014, section 11, p. 31

EENA Technical Committee Document, "Next Generation eCall", 11 December 2015

[86] *ETSI TR 103 140 Mobile Standards Group (MSG); eCall for VoIP*

MSD is proposed to be sent by the IVE and carried in the IMS signalling to transmit the data from the IVE to the appropriate PSAP by signalling means and not by the in-band modem.

The recommendations in ETSI TR 103 140 are:

- to use the initial SIP-INVITE message in the IMS emergency call for initial MSD transport
- to specify new URN sub-classes for IMS eCall for routing purposes, equivalent to the "eCall flag" used for in band eCall
- to specify a new system information indicator in 3GPP, to tell the IVS that the network supports IMS eCall
- not to use in-band modem over VoIP because modem signals may be impaired by de-jitter buffering.

Since IMS eCall will not relay on in-band modem MSD transmission, it will allow faster MSD transfer, no muting of speech path and two way data exchange providing this way "Next Generation" eCall (NG eCall). NG eCall will enable more comprehensive data set (e.g. regional specific data, medical data of the occupants, vehicle specific data), enhanced functionality (e.g. PSAP ability to view video streams from onboard cameras) and also send instructions to vehicle (e.g., sound horn, flash lights, lock/unlock doors, disable ignition).

The Internet Engineering Task Force (IETF) has published a document describing how to support eCall within the IP-based emergency services infrastructure[87].

7.4.6 Personal eCall

Current EU legislation only covers eCall for vehicles. Personal eCall[88] has been discussed in CEN TC 278 and in ETSI TC MSG but no standardisation has yet been done.

Personal eCall is essentially eCall initiated by a user from a mobile phone rather than (e.g. automatically) from a vehicle.

Personal eCall involves sending a modified MSD from a mobile phone to the PSAP using the same transfer mechanism as for vehicle eCall. For Personal eCall, the MSD can contain the current location of the mobile phone (and possibly information about the user of the mobile phone such as a name and address) instead of information about a vehicle as is used for current vehicular eCall. In the near term, MSD transfer can be via an in-band modem using the circuit switched 112 service; in the longer term a packet based solution can be used based on IMS Emergency Call or IMS Multimedia Emergency Service. Personal eCall could be deployed as a "smartphone app" on the mobile phone or as integrated functionality.

For near term Personal eCall, transient loss of voice connectivity (due to muting whilst the MSD is sent using the in-band modem) is a disadvantage. The loss of voice connectivity for typically 4

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[87] *IETF, "Next-Generation Pan-European eCall", 4 July 2014*

[88] *This section is used from the document:*

EENA NG112 Technical Committee Document, "Handset Derived Location for Emergency Calls", 19 November 2014, Annex C.2, p. 12 seconds (but potentially 20 seconds) may be problematic for emergency callers and may require the PSAP to change its operating policy. A method to mitigate the loss of voice connectivity could be to not to send the MSD at the beginning of the call, but instead let the PSAP request an MSD if needed. Existing eCall protocols allow this to be done. The PSAP operator could tell the caller that there will be a few seconds of silence whilst the data is collected.

A major advantage of personal eCall is that the data is inherently routed to the same PSAP as the emergency call and intrinsically attributed to that emergency call. Furthermore, there need not be any network impact and Personal eCall could be deployed quickly in cases where PSAPs are already eCall equipped. There would be no need for central server standardization, deployment, cost, or delay. The extent to which PSAPs will be eCall equipped will vary between countries. In the best case, when all PSAPs in a country are eCall capable, then Personal eCall would be a good solution. At the other extreme, where there is only one dedicated PSAP to receive eCalls and existing PSAPs that receive 112 calls are not eCall equipped, Personal eCall would not be so easily deployable.

A method to distinguish Personal eCalls from vehicle eCalls (manual and automatic) and from normal 112 calls is needed. Re-use of the existing vehicular eCall flags for Personal eCall can not be recommended because each category of call may potentially need to be handled differently. Ideally, a new flag for Personal eCalls would be standardised in 3GPP. There is only one spare bit in the emergency service category information element (ETSI TS 124 008) so it would be better to use this as an extension bit and use a bit in a new octet for Personal eCall. As an alternative, a new subscription option might be created that informed a network operator (e.g. an MSC) that any emergency call for a particular subscriber would support personal eCall. Both alternatives require some impact (probably small) to networks.

If there is no new flag and no new subscription option, then Personal eCalls would be routed to the same PSAP as other 112 calls. In this case, the PSAP may or may not be eCall capable. If the PSAP was eCall capable and knew that the UE was capable of Personal eCall, then the PSAP could "pull" the MSD. A UE may be able to indicate its capability to the PSAP by in-band signalling (e.g. DTMF tones) or some new control plane signalling. The latter would need 3GPP standardisation. If neither of these are deployed, and the PSAP is eCall capable but does not know the UE capabilities, the PSAP could still try to pull the MSD anyway; for instance during silent calls or as a last resort. As one alternative, users with phones capable of personal eCall could be registered (e.g. via their MSISDN) in some national database, which a PSAP could access to determine the capability. The database (which would need to be secure) might be populated by network operators and/or by users. This is not an elegant solution but appears low cost and avoids any new impacts to networks and any new inband or new control signalling.

A further consideration for Personal eCall deployed on CS emergency call is that the in-band modem was optimised for existing codecs and its performance with future codecs is not known.

Personal eCall deployed on the IMS Emergency Call or IMS Multimedia Emergency Service instead of Circuit Switched emergency call with in-band modem, would overcome all of the disadvantages mentioned above. Notably there would be no muting. Additionally, the call can be easily identifiable as Personal eCall by signalling elements allowing for the call to be routed, handled, and processed as desired by the emergency authorities. Furthermore, a migration path from circuit switched to IMS eCall has been defined in ETSI TR 103 140. Next Generation eCall is essentially the same as NG112 – the MSD is sent as additional data (see clause C.4). Being able to migrate from a CS version of personal eCall to an NG version should reduce changes at the PSAP side and, in particular, avoids the possibility of a legacy CS based solution continuing and causing problems in the NG era. It also avoids the expense of deploying an interim solution that is not identical to the long-term migration path.

7.5 OVERVIEW OF SOLUTIONS

The following table provides an overview of the existing caller location solutions to estimate the location of a handset during an 112 call.

	Network Based Location	Advanced Mobile Location	112 Apps	eCall
Positioning Method	Different Network Based methods and A-GNSS	Cell ID, GNSS, A-GNSS, Wi-Fi	Cell ID, GNSS, A-GNSS, Wi-Fi	GPS (GLONASS, Galileo, A-GNSS and EGNOS to be supported)
Transmission method	Signalling Channel of the mobile network	SMS	Depending on App implementation IP and/or SMS	Voice Channel
Does it require a data connection?	GNSS positioning methods require a data connection	No	Depending on App implementation	No
What handsets are supported?	Only GNSS positioning requires a GNSS enabled device. Other network based positioning solutions are handset independent.	GNSS enabled devices	GNSS enabled devices	Not applicable
Involvement of MNOs	Manage and coordinate the integration of location platform with the network elements.	Transmit the SMS free of charge	None	Implement the eCall flag Treat eCalls as 112 emergency calls (free of charge, priority, national roaming, etc.) Provide the right routing based on eCall flag following the instructions of the National Authorities Providing SIM cards for the IVE
Involvement of network vendors	Enable the required 3GPP standard interfaces (i.e. Lg, Lh, Lb) on their MSC, HLR and BSC respectively to connect the location platform nodes.	Ensure that the SMS can be sent during the emergency call (a network configuration parameter)	None	None
Involvement of handset manufacturers	n/a	Implement the AML functionality AML SMS message should be sent only in AML ready countries based on MCC/MNC to a short SMS number determined by MCC	None	Not applicable

	Network Based Location	**Advanced Mobile Location**	**112 Apps**	**eCall**
Involvement of application providers		None	Implement the app and ensure it complies with standards and the PEMEA architecture	None
Involvement of emergency services	Display the location in their CAD systems	Be able to receive the AML SMS and display the location in their CAD systems	Be able to receive the information from the app and display the location in their CAD systems Promote download & use of the app	Infrastructure set-up (e.g. integrate eCall into the PSAP systems) Verify that eCall information is correctly received Staff training Establishment of operational protocols
Advantages	Technology/handset/user independent – available today on 2G, 3G and 4G Very fast processing time 3GPP standard based – hence smooth integration with Mobile Networks. Can't be stopped or hindered by the mobile user	Simple to develop – rapid to launch Easy to deploy in countries where there is already a text to 112 service Transmission of location is automatically triggered without the need for manual user intervention AML can switch on GNSS services on the handset, even if it is switched off	Handset-based additional data can be made available to emergency services	Supported by legislation and standardisation A pan-European approach and works for roaming users Same prioritisation as a 112 call Minor changes required in the mobile networks (eCall flag and PSAP routing tables)
Disadvantages	Non GNSS Network based positioning methods have lower accuracy when compared to GNSS-based location	International roaming is not yet supported	Citizens need to download the app and remember to use it in an emergency situation User can switch off location services Apps work within their local or national boundaries, International roaming is not yet supported Many false calls are received	Takes longer than other methods to transmit the data The voice call is interrupted to transmit the data A lot of fake calls Based on old technology

Table 16: Overview of existing solutions for caller location of 112 calls

7.6 CURRENT STATUS OF DEPLOYMENT

Section 2 describes the existing implementations of caller location solution deployed by the member states. The only Network Based Location method currently used in Europe is Cell ID. No other, more precise, Network Based Location is used in Europe. AML is deployed and operating only in the UK currently, but other countries have shown interest and are planning AML deployment in the near future. 112 Apps are used in nine countries. eCall is currently being implemented in most countries, while personal and NG eCall solutions have not being deployed yet because they are at a conceptual stage.

Table 17 summarises the current status of deployment of the four existing caller location solutions in the 28 member states. The barriers experienced in the deployment of each solution are described in deliverable D1.3 Gap analysis, in section 4.

Solution	Number of countries that have deployed the solution	Comments
Network Based Location	28	Only Cell ID is used, no other more precise location method is used.
AML	1	
112 App	9	Some apps do not operate on a national level, or are used by specific emergency services, such as the ambulance service.
eCall	4 countries have implemented eCall and in 4 countries it is under development[89].	eCall is currently under implementation. Personal and NG eCall are not finalised solutions.

Table 17: Current status of deployment of the four existing caller location solutions in the 28 member states.

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[89] *Based on data at the end of 2015, as found in:*
EENA, "Public Safety Answering Points in Europe, 2015 edition", November 2015, Annex 1, p. 231

8. CONCLUSIONS

Caller location determined by Cell ID is the solution currently available in all member states. While the solution has great availability and response time, its lack of accuracy and precision makes it unsatisfactory for the effective operation of emergency services. Therefore new solutions are sought that can also take into account the vast availability of handsets with GNSS receivers as well as the existing capabilities of network based location solutions, furnishing location precision and accuracy higher than Cell-ID and possibly acting as a safety net.

This deliverable covers the state of the art analysis of existing caller location solutions and the considerations for their future versions taking into account the new capabilities of the availability of LTE networks. In order to study each solution, the available positioning and transmission methods have been isolated and studied individually regarding their expected availability, accuracy, response time, and their advantages and disadvantages. The deliverable also looks at the four complete solutions currently existing, Network Based Location, AML, 112 Apps and eCall.

GNSS and A-GNSS methods provide the greatest level of accuracy, which is acceptable and desirable for emergency services. Their availability and accuracy may be reduced in cases of no sky visibility, indoors and in urban canyons. However, this can be compensated by Wi-Fi positioning and the availability of GNSS positioning by multi-constellation and augmentation systems. Network based positioning methods generally provide location with lower precision but they do play a significant role as a safety net when GNSS location is not available either because of the location or because the handsets are not equipped with GNSS capabilities.

Different communication channels have been described for transmission methods. There is no doubt that IP paves the way for the future of caller location for an emergency call. However, this should be considered as long term solution, when the availability of LTE networks will grow significantly. In the short term, SMS is a method available whenever an emergency voice call can be placed. Transmitting the location data in the voice channel as in the case of eCall is considered an old technology that will be replaced by IP.

The four existing solutions of caller location have been described as combinations of the available positioning and transmission methods. Their advantages and disadvantages have been identified in addition to the different actors involved in their respective deployments. Network based location requires more involvement of MNOs that the other solutions but on the other hand does not require the involvement of handset manufacturers. AML requires the involvement of handset manufacturers but requires less involvement from the MNOs. 112 Apps require no involvement from either the MNOs or the handset manufacturers, but they need continuous efforts to promote the download of the App and remind citizens to use it in case of emergency. With the emergence of several apps from different countries, it becomes critical to achieve a Pan European Architecture for the 112 Apps that can ensure that all apps will be able to operate across Europe in the user's preferred language.

The analysis of the state of the art is the second milestone of the comprehensive analysis in the context of HELP112. This deliverable and deliverable D1.1 Requirements Document that describes the requirements of the pilot sites are the two inputs to the D1.3 Gap Analysis. D1.3 will cover a detailed gap analysis of the user requirements and the state of the art to identify the solutions that satisfy most of the requirements and in the best possible way, while also looking at which parts of the existing solutions could be reused in the context of HELP112.

END OF DOCUMENT