Digitising European Industry initiative

Working Group 2:
Strengthening Leadership
in Digital Technologies and in Digital Industrial Platforms
across Value Chains
in all Sectors of the Economy

Second report

22 February 2017

Contents

Executive Summary

Industry constitutes one of the main pillars of the European economy, with an impact that significantly exceeds the size of the sector itself. Digitisation can strengthen industry's position as an engine for growth and prosperity in Europe, a provider of "real jobs" and a source of innovation. However, in other parts of the world very significant investments in digitisation occur as well. Without concerted action European industry may miss crucial opportunities and even be left behind.

Against this background the Digitising European Industry (DEI) initiative aims to ensure that any industry in Europe, large or small, in whatever location and regardless of industrial sector can fully benefit from digital innovation to upgrade its products, improve its processes and adapt its business models to the digital age. The DEI initiative aims towards:

- Coordinating initiatives for digitising industry across Europe;
- Co-investing in Europe's digital innovation capacities;
- Providing appropriate regulatory framework conditions;
- Providing human capital with the necessary skills for the digital transformation.

The implementation of the DEI initiative is supported by a Roundtable of high-level representatives of Member States' initiatives, industry leaders and social partners, as well as two Working Groups (WG):

- WG1: Mainstreaming digital innovations across all sectors;
- WG2: Strengthening leadership in digital technologies and in digital industrial platforms across value chains in all sectors of the economy.

This report deals with the work of WG2.

WG2 has held two meetings (on 21 October and on 8 December 2016), receiving input from stakeholders. At both meetings the preferred approach was discussed in plenary sessions, and in more detail in subsequent parallel sessions organised around three "vertical" perspectives: Connected Smart Factories, Smart Agriculture, and Digital Transformation in Health and Care. These were chosen as examples of target markets/industrial domains for which digital industrial platforms could be seen as adding value. Obviously, this also applies to other domains, such as Smart Mobility, Smart Energy, and Smart Finance (Fintech), which were not tackled by this WG. However, two "horizontal" perspectives were also addressed in WG2: Industrial Data Platforms and the Internet of Things (IoT). While the level of detail of the debate and the resulting findings and recommendations showed differences in each subgroup, they nevertheless reflected an overall high level of consistency within WG2. WG2 released a first report on December 23, 2016, which triggered further feedback and discussion. During the First Stakeholder Meeting on January 31 – February 1, 2017 in Essen the report was further discussed during a dedicated session. Based on the discussions at these meetings and on additional input received, the main conclusions are as follows.

Firstly, it is clear that many initiatives to create platforms for industry already exist across Europe as they do in other parts of the world. For instance, in IoT alone 360 platforms exist around the world. Overall investment levels are substantial and will further increase in the coming years. However, a comprehensive stocktaking of relevant projects – the basis for efficient European action – is not yet complete. Member States were thus encouraged to provide information about projects within their borders, to achieve a comprehensive overview of opportunities for the sake of a joint road mapping exercise.

Secondly, stakeholders in WG2 expect the current landscape with a plethora of platforms to evolve towards a situation with at most a few dominant ones per vertical. They do not encourage a heavy-

handed “holy-grail”-type pursuit of a one-for-all platform. Instead they recommend that a joint effort is undertaken to create an environment for the validation of new approaches.

Such an environment requires a type of “glue” connecting promising initiatives, to leverage their visibility, impact and economies of scale and to maximize network benefits for the user communities. This is why a federation of bottom-up initiatives, especially across national borders, needs to be promoted. PPPs can play an important role in this process.

Last but not least, the validation process that would thus be facilitated is not just a technical matter. The assessment if an approach could work should also take into account socio-economic effects and should therefore take into account the feedback from a broad range of stakeholders such as consumers, unions and legislators. It is for instance important that the benefits of the platform should be distributed in a fair way, it should offer an inclusive solution and it should respect fundamental values of transparency, ownership and democratic control. Participants emphasized the associated legal, economic and social challenges of digital platforms which are not trivial. For example, privacy concerns regarding the sharing of data – probably most explicit in Europe in the Health and Care domain, but also for worker-related data – need to be taken seriously into account as they can easily create barriers to user acceptance. The legal aspects of what “sharing” of data means need to be addressed thoroughly, preferably in a way that creates legislative harmonization and clarity across the EU. The Industrial Internet's implications on a range of legal issues (e.g. IPR management, liability, unfair competition and consumer protection) need to be urgently considered and in detail, especially vis-à-vis international developments. Such an effort early on would prove beneficial to the proliferation of Industrial Data Platforms across jurisdictions. An EU Communication regarding this issue was launched in January, 2017. Furthermore, many of today's employees do not have the knowledge or possess the skills to make them fit for the digital age. Sufficient attention should therefore be given to education and training, in tandem with technology development, to avoid a further deepening of the Digital Divide and a subsequent erosion of the social capital base. Only on the basis of adequate education and training will DEI efforts provide the leverage for achieving the EU’s broader socio-economic goals.

In conclusion, the most immediate action, recommended by WG2, should be further and more intense communication between the EU and the Member States. By comparing initiatives and exploring opportunities for the development of joint roadmaps, initiatives can be effectively federated, and the diversity of existing regulations successfully addressed for the benefit of Europe's industry and its citizens.

The debate is ongoing. The Working Group will produce a further updated report in a few months' time.

1. Introduction

1.1 Background

Industry constitutes one of the main pillars of the European economy. Digitisation offers impressive new opportunities to strengthen the position of European industry. According to reports by PwC[1] and Boston Consulting Group[2] digitisation of industry would offer benefits that could generate for industry in Europe an additional annual revenue of € 110 billion. As opportunities of digitisation are recognized around the world, triggering a corresponding level of investments across the globe, digitisation can be either an opportunity or a threat, depending on the timeliness and the adequacy of one's response to it.

Against this background the Digitising European Industry (DEI) initiative aims to ensure that any industry in Europe, large or small, wherever situated and in any sector can fully benefit from digital innovations to upgrade its products, improve its processes and adapt its business models to the digital age. This requires not only a dynamic digital sector in Europe but also the realization of full access to digital innovations across all industrial sectors. This policy is set out in detail in a Communication[3] adopted in April 2016. The DEI initiative aims towards:

- Coordination of initiatives for digitising industry;
- Co-investing in Europe's digital innovation capacities;
- Providing the appropriate regulatory framework conditions;
- Providing human capital with the necessary skills for the digital transformation.

The DEI initiative requires ambitious collective effort involving public and private stakeholders across Europe at regional, national and EU level. A key element of the DEI is concerted action to strengthen Europe's leadership position in digital technologies and digital industrial platforms across value chains in all sectors of the economy. The implementation of the DEI initiative is being supported by a Roundtable of High-Level Representatives of Member States' initiatives, industry leaders and social partners, to be held twice a year. The first Roundtable was held on September 20, 2016 in Brussels.

To support its work the Roundtable has set up two Working Groups in order to make progress on aspects of the implementation of the DEI Action Plan. The focus of the two WGs is as follows:

- WG1: Mainstreaming digital innovations across all sectors;
- WG2: Strengthening leadership in digital technologies and in digital industrial platforms across value Chains in all sectors of the economy.

Each WG is expected to produce a report supporting the implementation of specific DEI actions. The WGs will perform fact finding, collect best practices and formulate recommendations, e.g. on policy matters and mobilisation and leveraging of investments, addressed to the High-Level Representatives attending the Roundtables. This report concerns the results of WG2.

1.2 Outcomes and deliverables

The September 2016 Roundtable has issued WG2 with the following mandate:

[1] http://www.strategyand.pwc.com/media/file/Industry-4-0.pdf

[2] https://www.bcgperspectives.com/content/articles/engineered_products_project_business_industry_40_future_productivity_growth_manufacturing_industries/

[3] Digitising European Industry (DEI): Reaping the full benefits of a Digital Single Market. Communication (COM(2016)/180)

- Reflect on the **priority development of building blocks by the PPPs**, as well as how **Member States could commit to align and co-invest** on the same industrial priorities in order to reach critical mass. The reflection shall include consideration for the role of Member States in the PPPs.
- Reflect on how **building platforms should be approached on a European and national level** and how ICT could be mainstreamed in the national R&I programmes.
- Reflect on the form and objectives for **further EU and national platform-related projects and/or large-scale testing and experimentation pilots**, how PPPs can align their strategic research agendas to develop the necessary platforms, large-scale pilots and standards, and how national efforts could be combined in an overall support.
- Reflect on the **prioritisation of several initiatives under preparation**, covering both: integration platforms addressing cross-sector challenges (Leadership in IoT, Industrial Data Platforms, and 5G demonstration); and sectoral platforms and full solutions (Connected Smart Factory, Connected and Automated Driving, and Robotics, IoT and AI for healthy living and active ageing).
- Reflect on further support to **the full roll-out of digital integration platforms**. The WG is invited to develop **more integrated funding schemes** (covering European, national and regional as well as private investments, including the use of financial instruments like EFSI) for other technology roll-out initiatives in areas such as 5G or Connected Automated Driving. It shall also encompass considerations for public procurement of innovations and framework conditions.
- Propose whether specific platform initiatives would deserve attention of one or more subgroups.

WG2 was tasked to develop a report according to the following schedule:

- A first draft of the report before the end of December 2016;
- A revised draft for the DEI Stakeholder Forum (end of January 2017);
- A final version for April 2017.

The working group quickly found the original mandate from the Roundtable overly broad, unrealistic, and unfocused. Therefore, a narrower, more precise objective was adopted.

WG2 aims to support the creation of next-generation digital platforms by defining possible next-generation platforms, reflecting on how building platforms should be approached on European level, and considering how existing and planned EU-wide, national, and/or regional platform development activities can contribute.

WG2 considers next-generation digital platforms in the following sectors/topics:
- Connected Smart Factories
- Smart Agriculture
- Digital Transformation of Health and Care
- Industrial Data Platforms
- Internet of Things

1.3 Methodology and process

WG2 has held a first meeting in Brussels on 21 October 2016. Around 80 representatives from industry (including SMEs), the research community, Member States, regions, and social partners attended and addressed a series of questions related to the above mandate. The meeting included a series of scene-setting presentations and more focused discussions and exchanges within a series of parallel sessions. These parallel sessions focused either on specific vertical areas (Smart Agriculture,

Connected Smart Factory and Digital Transformation of Health and Care) or on horizontal issues (Industrial Data Platforms and Internet of Things). This first meeting focused on four key issues:

- What is the current landscape of platform development and related activities in Europe?
- What is the vision for where we should go next?
- How do we bridge the gap between what we have and what we want to achieve?
- Who are the main stakeholders to be involved?

Building on the results of the first workshop and on the inputs received in the weeks following it, a second meeting was held in Brussels on 8 December 2016. Again approximately 80 representatives from a variety of organizations and Member States attended. Similar to the schedule used during the first meeting, the second meeting included a plenary session and more focused discussions in parallel sessions. The parallel sessions were devoted to the same five areas that featured in the first meeting. The second meeting focused on the following four issues:

- Stocktaking of results so far;
- Developing further ideas for next-generation platforms;
- The type of supporting initiatives needed;
- Suggestions for action plans, including possible contributions from PPPs and links with national initiatives.

After these meetings a first report was released on December 23, 2016, reflecting the finding and conclusions after the two meetings and the collection of feedback in the first months. Subsequently more contributions were received. During the First Stakeholder meeting in Essen (January 31 – February 1, 2017), WG2 organised an open session where the report was further discussed. This feedback and other contributions have been used to produce this second updated report.

After an introduction of the general approach in Chapter 2, the report presents the more specific findings and recommendations per area in the subsequent chapters. First the findings for the three vertical areas are discussed in Chapters 3-5. Then the results for the two horizontal areas are presented in Chapters 6-7. A conclusion is provided in Chapter 8.

The report will be updated based on the continuation of the debate in WG2 in the coming months.

2. Establishing European Leadership in Next-Generation Digital Platforms

2.1 Mastering digital value chains

It is recognized around the globe that effective use of digital technologies is key to competitiveness in the modern world. Across all industry sectors mastery of digital technologies and platforms in value chains – and the consequent ability to create a digital thread[4] that connects all operations involved in producing goods and services – offers very significant opportunities to create value for the customer and to strengthen the competiveness of industries and firms.

The change associated with this digitisation of industry is driven by the convergence of three key technological trends related to:

- Connecting "things" to the digital space (driven by IoT – embedded software, sensors, actuators, connectivity, low power ICT etc.);
- Creating value from knowledge (driven by (Big) Data Science, HPC, cloud computing etc.);
- Deploying autonomous systems (driven by robotics, automation, machine learning, etc.).

Together these trends facilitate digital innovation in products, processes, services and business models in all industry sectors.

Europe has key strengths to contribute to these developments. For instance, from a social point of view, European industry has an advantage in the realisation of digitisation since it tries to keep humans in the loop, use their ability to discover meaning in the value chain and on this basis achieve a world-class performance. At the same time, important gaps exist in Europe's profile to lead the creation of digital value chains. Most notably, efforts – from R&D to experimentation to deployment – are often spread across Europe and are fragmented, making it difficult to reach the critical mass that is needed for a position of world leadership.

2.2 From development of technology to full solutions

The Background Note to the 20 September 2016 Roundtable on Digitising European Industry foresees three stages, each with different requirements in terms of the means and intensity of public intervention:

1) Research and development of technology and systems building blocks. This can be addressed through better alignment of national R&D&I programmes, both with each other and with EU programmes around strategic priorities established in PPPs.
2) Development, validation and piloting of digital industrial platforms. This can be addressed through co-investment in large-scale integration, testing and experimentation facilities.
3) Roll-out of digital industrial platforms. This can be addressed through co-investment in large-scale deployment actions (support to first production, infrastructure, etc.).

This step-wise increase in the scale of the initiatives and of their impact on society at large is illustrated in Figure 1.

[4] http://www.mckinsey.com/business-functions/operations/our-insights/digitizing-the-value-chain

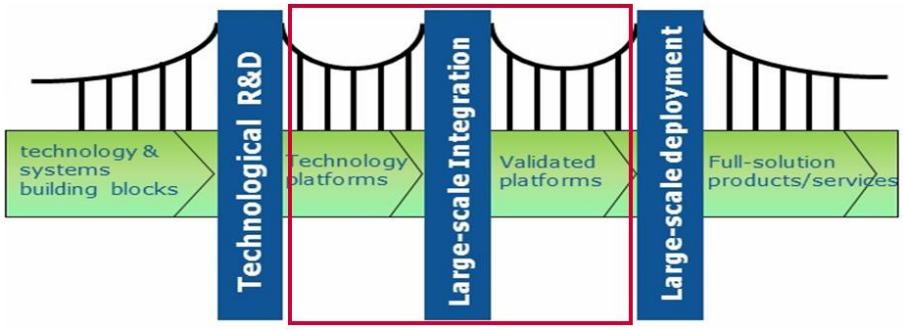


Figure 1: The step-wise introduction of digitisation in industry

The work of WG2 will focus on the second stage. Thus, the emphasis is on establishing digital industrial-scale technology platforms and large-scale integration. Large-scale deployment is not addressed in this working group at this stage.

2.3 Digital platforms and their roles

WG2 focuses on the challenge of creating the next-generation digital platforms and using them to enable the digital ecosystems that will be vital for an increasing number of economic sectors. Note that the term 'platforms' has several different meanings. Commissioner Oettinger likes to talk about a "platform of national initiatives" or a "platform of platforms". In this context, examples of national initiatives are *Plattform Industrie 4.0* in Germany, *Industrie du Futur* in France, *Piano Nazionale Industria 4.0* in Italy, and *Smart Industry* in the Netherlands (see Figure 2 below). This interpretation of 'platform' as a place or opportunity for public discussion is not the interpretation in this report.

Figure 2: National initiatives

The DEI Communication defines platforms as "multi-sided market gateways creating value by enabling interactions between several groups of economic actors".[5] Digital platforms are like operating systems that integrate different technologies and various applications and services. They open up data and make it accessible, allow third-party innovation on top and connect different

[5] COM(2016) 180 final, 19 April 2016

stakeholders, such as users and application developers. In general, three main aspects/roles can be distinguished in platforms[6]:

1. In a community role, platforms may have users explicitly connecting with each other, as in social networks. Some may have users exchanging items as in marketplaces. The community is where third-party producers create value and is a key source of value for the platform. To enable this value creation, the next role is needed.
2. In an infrastructure role, platforms provide infrastructure and functionality, and more importantly, allow users and partners to build applications and create value on top of this infrastructure. This openness to and reliance on third-party complementary applications determine the value of platforms: more developers working on the platform create more applications; more applications make the platform's offering more valuable, and results into more customers using the platform; more customers using the platform attracts more developers. The infrastructure role also channels the data that the platforms unlock and integrates different technologies and systems.
3. In a data role, every platform makes data accessible and uses data in some way. In many cases, data serves to provide relevance, matching the most relevant content/goods/services with the right users. In other cases, the value may exclusively lie in the data that is made available from connected applications, sensors and devices.

Different platforms fill in the above three roles in different ways and to varying degrees. Some focus more on connecting users and providers (e.g. Facebook), some on unlocking data (e.g. Nest), and others act as development platforms for third parties (e.g. Android). We see a combination of the three roles in many real-life examples.

It should be noted that we do not consider online platforms in the consumer world, but **industrial platforms** in the business wold. Both worlds differ. Online search and social-networking services are easy to scale, because the needs of human beings are similar across the world. Particular industries and companies, on the other hand, often have specific requirements that call for customised products[7].

A few examples of ongoing platform development activities are given in Annex A.1.

2.4 Large-scale piloting and testbeds

Digital platforms can be validated in large-scale pilots and testbeds by usage and development of prototype applications on top of the platforms. In large-scale piloting, pilots are set up that make use of the digital platforms, develop prototype applications on top of the platforms, and validate the platforms. Both reduced, controlled environments and real-life use cases can be used to validate the platforms and complementary applications. Pilots may adapt platforms to specific application needs and validate their relevance for such needs, in order to foster take-up and large-scale deployment. Pilots cover innovative application scenarios with high socio-economic impact making use of the digital platforms.

A few examples of ongoing large-scale pilots and testbeds are given in Annexes A.2 and A.3.

2.5 Ecosystem building and standardisation

In ecosystem building, the take-up of digital platforms is fostered by increasing the ecosystem of players involved and by standardisation activities. For instance, small and innovative ICT players

[6] Adapted from http://platformed.info/platform-stack/

[7] http://www.economist.com/news/business/21711079-american-industrial-giant-sprinting-towards-its-goal-german-firm-taking-more

such as SMEs can develop services/applications with a clear societal and economic value, on top of the digital platforms. Moreover, additional small-scale pilots can be conducted by SMEs, validating the digital platforms and prototype applications.

Furthermore, to achieve a truly integrated digitised European industry, the implementation and development of standards that are based on broad, international consensus of companies, users, governments and other stakeholders are vital. Standardisation contributes to compatibility, interoperability, quality and safety of products and processes. Therefore, platform development activities, large-scale piloting, and ecosystem building need to be complemented by contributions to suitable standardisation bodies, leading to new or better standards as outlined in the Communication on Priorities of ICT Standardisation for the Digital Single Market.

2.6 Towards large-scale federating initiatives

The European Commission expects to launch a number of projects in the 2018-2020 timeframe that will make a significant step forward in platform development, interoperability between existing platforms, integration of relevant digital technologies such as Internet of Things, Artificial Intelligence, photonics, robotics, cloud and Big Data, and validation via pilots and experimentation facilities. Starting from suitable reference architectures, platforms will be defined, tested via piloting, supported via ecosystem building for their roll-out, and evolved into standards.

Various platform development activities, large-scale piloting, and testbeds exist at EU or national level. Projects developing the next-generation digital platforms, including the aforementioned projects in 2018-2020, need to bring together various EU and/or national programmes and act as linking pins. These projects need to build on existing platforms, pilot sites, testbeds, and experimental environments that have been developed in various (national) programmes. As such, these projects provide the "glue" to connect currently disparate projects, programmes, and initiatives.

Figure 3 shows an example from the Connected Smart Factory domain, where platform development and integration activities link to several ongoing initiatives (e.g. model factory, experimentation lab, digital innovation hubs, real production sites), pooling investments from various sources (by e.g. Member States, regions, industry, and EU).

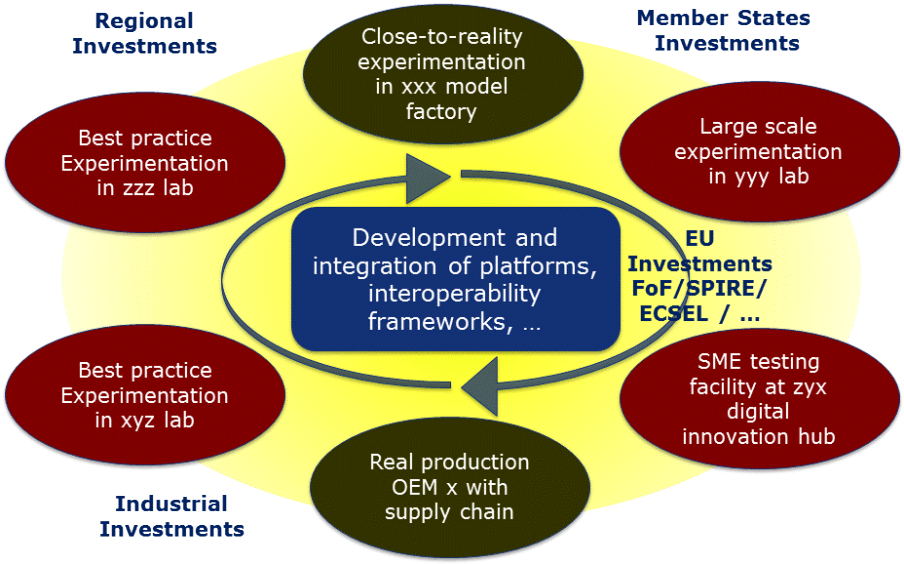


Figure 3: Approach to achieving leadership in digital technologies value chains

Annex A presents information about some of the more relevant programmes, projects and initiatives on European and national level, so that future activities may establish links, where appropriate.

Advances towards large-scale initiatives can trigger the development of new scalable business models. Such models may be disruptive, e.g. when coalitions of users (e.g. farmers, machine owners, hospitals or telcos) pool their data to increase their power over suppliers or when service providers work together with users to share and process data in ways that create new value and new business opportunities. In this respect digitisation has enormous potential to fundamentally change operations in many sectors, and in fact in how we lead our lives. Therefore, the creation of large-scale initiatives should pay close attention to the alignment of the envisaged business models with fundamental European socio-economic values. To this end, involvement of a wide range of stakeholders is very important, to anticipate obstacles and produce a truly balanced result.

Opportunities for large-scale federating initiatives per vertical and horizontal focus area are discussed in more detail in the next chapters.

2.7 Role of Public-Private Partnerships

The previous section illustrates the approach of large-scale federating initiatives. It also illustrates the role of ongoing activities on national and regional level, whether they are focused on platform development, large-scale piloting, or testbeds. Public-Private Partnerships could play an essential role here as well.

In general, Public-Private Partnerships (PPPs) play a number of roles in European research, technology development, and innovation. They are an important means to develop the technology building blocks which underpin the digital revolution. They are also of significance to obtain the level of scale that is required for large-scale experimentation and standardisation. Furthermore, testbeds developed within PPPs can play an important role to create consensus about approaches and solutions, initially inside sectors but partly also across them.

The Digitising European Industry initiative advocates the continuation of the development based on PPPs and expand the project portfolio of the PPPs to further address the goals outlined in the DEI action plan. This means that greater coordination is required between the different PPPs. It also means that their Strategic Research and Innovation Agendas (SRIAs) should be better aligned to reach critical mass. Besides alignment and better articulation of efforts, the DEI Communication foresees focused investment by the EU, Member States and industry. The proposed approach is to maintain and reinforce the European support in Horizon 2020 to the PPPs in core technologies. Simultaneously, national programmes could align with the priorities defined within these PPPs, and v.v.

The exact role of Public-Private Partnerships in the large-scale federating initiatives approach towards platform development, large-scale piloting, and ecosystem building, as outlined in this chapter, needs to be made more concrete.

3. Overview of the Strategy in "Connected Smart Factories"

3.1 Introduction

Value chains in manufacturing are changing across the board, becoming more integrated and more complex. Industry-driven platforms are widely seen as a strategic requirement for Europe to master these new value chains. The European Roundtable of Industrialists has called for greater efforts to drive global standards for the industrial Internet and to foster industry-driven platforms.[8] EFFRA, too, sees interoperable digital manufacturing platforms as central to its vision for factories of the future.[9]

Digital platforms provide a means of addressing the many challenges facing manufacturing in the twenty-first century. They are to:

- Enable **more agile and flexible approaches**, in line with new delivery and service opportunities ('Logistics 4.0').
- Facilitate **mass customisation** (so-called 'lot size one'), allowing every product to be unique and custom-made.
- Allow **autonomous and Artificially Intelligent (AI) systems to be integrated** into the manufacturing environment – so-called 'cobotics'.
- Promote **excellence**, eliminating defects in processes and products and allowing human competences to be developed in synergy with technological assets.
- Provide **a means to bridge two key trends**: fully linked physical and digital worlds, on the one hand, and fully-linked products and production, on the other.
- Enabling **servitisation** of manufacturing, creating substantial opportunities through intelligent service-after-sales on top of the revenue created by the sale of the core product.
- Improve **energy and resource efficiency** and create **more sustainable value networks**, key steps towards making the Circular Economy a reality.

It is clear that the Circular Economy requires an enormous traceability of industrial products in order to define where individual products are sourced, produced, disposed of, etc. This will create major data requirements across the whole value chain and could make the Circular Economy a key market driver for the digitisation of industry. Similarly, the concern for better resource use and less stress on the environment is also a main driver for smarter approaches in Agriculture (see Chapter 4).

European policy aims to ensure that future global standards and platforms for the Connected Smart Factory are driven by the interests of EU actors; and that to achieve this, EU actors join forces along common interests in the 'platform economy'.

3.2 Current landscape of activities

3.2.1 European initiatives

Key initiatives at the European level are the PPPs. Two PPPs explicitly address manufacturing/production: Factories of the Future (FoF) (discrete manufacturing) and Sustainable Process Industry (SPIRE) PPP (industrial processing). The role they could play towards the DEI objectives will be detailed in section 3.5.

[8] ERT Position Paper: Towards European Leadership in the Industrial Internet (August 2016)
[9] EFFRA Recommendations: Factories 4.0 and Beyond (Sept 2016)

3.2.2 National and regional initiatives

Developments are also underway at national level in many Member States. The Netherlands, for example, has the *Smart Industry* initiative, including 25 field labs established as high TRL environments. Some of these actions are clustered around the EU's Vanguard initiative which itself has many of the characteristics of a platform. Germany started the *Industry 4.0* initiative, connecting embedded systems technology and smart production processes to enable smart factories. During the past year key players in the initiatives in the Netherlands and Germany have signed agreements, committing themselves to standardisation. For example, the ProSTEP iViP Association in Germany has developed a "Code for PLM Openness" (CPO) which provides a criteria catalogue for interoperability, infrastructure, extensibility, interfaces, standards, architecture, etc. to business users and hence opens the way for transparency in digital industrial operations (see Figure 4).

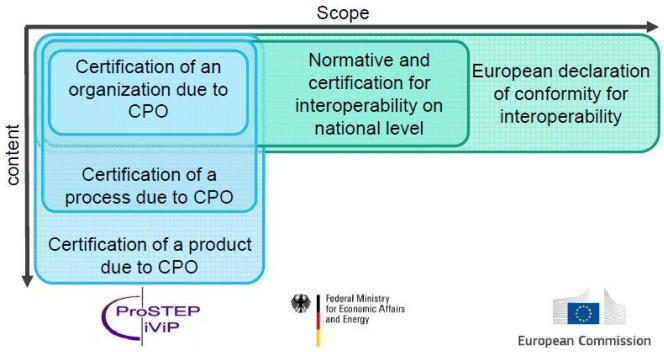


Figure 4: Towards a European CPO certification roadmap

Sweden introduced the *Produktion 2030* initiative to boost digitisation of its manufacturing industry. Spain has also launched an Industry 4.0 initiative and is experimenting with various approaches. Italy's National Industrial Plan, announced in September 2016, foresees investment by government that will be matched by industry. It includes investment in competence centres and digital innovation hubs, some of which will be linked internationally. In France, the Industry of the Future Alliance (*Industrie du Futur*) was launched earlier this year, aiming to strengthen the country's global position as a leader in new industrial systems. Several cooperation agreements have been signed since then between French organisations and those in other countries, most notably in Germany. In December 2016, *Plattform Industrie 4.0* and *Industrie du Futur* jointly released a Joint Working Program and a Common List of Scenarios.

3.2.3 International initiatives

Obviously, in North America and Asia relevant developments regarding Connected Smart Factories occur as well. PwC predicts a global investment level in technologies for industry digitisation in 2020 of more than $ 900 billion annually. It also reported that 72% of the companies included in its survey expect to have achieved "advanced levels of digitisation" by then, compared to 33% today[10]. A growing awareness exists in the business communities of what these levels of investment imply in terms of market opportunity for platform suppliers. "The Economist" recently compared the GE approach, based on Predix, and Siemens' MindSphere to assess their chances on eventually dominating the industrial Internet[11]. It concluded that a single platform is unlikely to achieve a position of total dominance and stressed the importance of an "open" approach. This only emphasizes the need to carefully follow international initiatives and develop relations with them.

[10] http://www.pwc.nl/en/industry-4-0.html

[11] http://www.economist.com/news/business/21711079-american-industrial-giant-sprinting-towards-its-goal-german-firm-taking-more

In the US the transition towards Industry 4.0 is strongly driven by large companies, such as AT&T, Cisco, IBM, GE and Intel. In the past two years more than 250 other companies, including several from Europe, have joined the US-led Industrial Internet Consortium (IIC), which aims to coordinate the priorities for the industrial Internet and to enable the related technical applications. IIC focuses on progress through test beds in specific application domains, as opposed to more generic standard setting. Close contacts exist between the IIC and European companies. For instance, Bosch played a prominent role in the first IIC test bed, about the connection of tools and work steps in aeroplane maintenance.

Likewise, Chinese companies have shown a keen interest in the European developments regarding Connected Smart Factories, especially in Germany's Industry 4.0 initiative and its stakeholders. However, they take a different approach, relying more heavily on direct investment in European companies that are relevant for them. For instance, in the past year Chinese companies have invested quite substantially in German companies that are affiliated with Industry 4.0, such as tool manufacturer KraussMaffei, H.Stoll and Manz and robot maker Kuka. Bearing in mind the demographic changes in China the government supports a transition away from an Industry 2.0 context, which emphasizes low labour cost and exploits the availability of a vast labour force. However, to overcome reduced availability of workers and rising labour costs it still stresses investments in automation, especially robots, more than investment in connection and truly smart factories. It also puts less emphasis on the development of skills for the digital age. Nonetheless, the Chinese investment level in relevant technology is very significant and exceeds the level of investment in the EU. The two most relevant programmes in China are "Made in China 2025", often considered the Chinese equivalent of Industry 4.0, and Internet Plus (IP)[12]. Towards 2025, IP aims to increase security of and access to Internet, to improve the convenience of (Internet-based) social services and to link manufacturing and retail in an effort to move away from labour-intensive manufacturing towards activities with more value added.

3.3 Visions for the future

3.3.1 Needs and expectations

In Europe, a substantial level of fragmentation exists in the area of Connected Smart Factories. Many initiatives can be found already, with different motivations, objectives and funding streams. Less fragmentation is clearly desirable. Strong agreement exists in WG2 that joint attempts should not aim for the creation of a "holy grail" solution: a single platform for everyone. Future initiatives must reduce limitations to access that currently exist as a result of fragmentation and due to lack of interoperability, while supporting an approach that is socially sustainable.

3.3.2 Bridging the gaps and addressing the issues

Given the needs and expectations regarding Connected Smart Factories it is clear that at the technical level, interoperability and integration of legacy systems should be a key focus for testing and validation efforts. Standardization is an important instrument to enhance interoperability. Interoperability is especially important in the context of federating initiatives where activities seek to build on what has gone before (i.e. a so-called 'brownfield approach'). Such an approach is for instance being followed in the five pilots being launched by AIOTI. These will be multi-stakeholder efforts from the outset so as to create trust and confidence across the community.

Economic considerations also play an important role in the context of Connected Smart Factories. On the one hand demonstrating added value is key to successfully establish digital platforms. The platforms have to meet – and be shown to meet – the needs of their stakeholders, especially the users.

[12] http://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf

This means a strong emphasis on validation, demonstration and experimentation in realistic settings (labs, test beds, pilot lines, twin digital factories). Moving from the laboratory into realistic facilities creates trust and confidence for all concerned – large enterprises, SMEs and users. Initiatives must reach out to engage with SMEs, start-ups and entrepreneurs. Like other stakeholders, SMEs will engage if they see and understand the benefits: new customers, price advantages, etc. Specific measures – data spaces, support projects – will be needed for this and should be part of concrete actions. However, for SMEs especially the levels of investment have to be feasible. Here digital innovation hubs can play a key role, because they provide a threshold to access that is low. A promising approach with regards to validation and standardization that is specifically aimed at the needs of SMEs is taken within the context of Industrie 4.0, through the Labs Network Industrie 4.0[13] together with the Standardization Council Industrie 4.0.

Furthermore, platform success is very much driven by the exploitation of network externalities: the networking potential that a platform offers to an aspiring user depends heavily on how many other users are already connected to the platform. As a result there is a strong tendency for a trajectory where a few winning platforms eventually take all users and a oligopoly or even monopoly results rather easily. Such an outcome would make it tempting for the winning platform providers to force users to pay more than they normally should for existing services and it would reduce the drive for new and better services.

In the debate about "the user" one should bear in mind that traditional distinctions between platforms for business-to-business (B2B) versus business-to-consumer (B2C) operations look increasingly outdated. As value chains become more integrated, it becomes ever more difficult to separate the business and consumer dimensions. Google, Amazon and Facebook, for example, largely position themselves as consumer platforms, yet the majority of their revenues come from B2B activities. The media industry reacted too late to this situation and has suffered significantly at the hands of new entrants who have become monopolistic gatekeepers. Europe cannot afford other sectors – e.g. automotive, smart homes, smart cities – to go the same way. To safeguard their position these sectors have to become more focused on the consumer and invest in servitisation.

The legal regime is also important, for issues such as IPR. Clearly the fact that data will be more accessible does not mean that it always has to be provided for free. Yet, all players need to be able to compete without giving up their data or paying fees that would be incompatible with their business model. This issue will be discussed in more detail in the chapter about Industrial Data Platforms (Chapter 6).

3.3.3 Priorities

Stakeholders in WG2 considered the priorities for this area to be as follows:

The stock taking of relevant initiatives should be completed as soon as possible
It is clear that many relevant initiatives already exist and while they are all somewhat different they also have much in common. Opportunities for collaboration and joint effort clearly exist. Together with the EU, Member States should perform a more detailed assessment of their national initiatives and how they could be strengthened by further synchronization.

Experimentation should be encouraged
WG2 advises against "Big Bang" attempts to launch a new platform and make it the preferred solution for everyone. Instead, experimentation with different solutions should be encouraged. This applies especially to for instance Manufacturing as a Service (MaaS), platforms for the Circular Economy, collaborative engineering, additive manufacturing and real time advanced factory analytics.

[13] http://lni40.de/en/

The scale of successful initiatives should be leveraged through federation
Instead of introducing a single big new initiative, existing platforms should be connected and leveraged through federation. Enhanced platform connectivity based on the definition and use of common APIs can facilitate this. This should be accompanied by enhanced security measures, e.g. against cyber attacks. This will help to remove doubts about the reliability of the platforms and increase the acceptance among potential users.

Besides technical aspects economic, legal and social issues should be addressed as well
Sufficient attention should be given to the social effects of establishing connected smart factories. Educational programmes at various levels should equip (future) workers in European industry with the knowledge and skills to address the challenges of the digitised world. Legal and economic safeguards against the risks of monopolistic positions of platforms need to be in place. Obviously, this should not strangle promising initiatives or putting undue pressure on the direction of their development. Nonetheless, the regulation should effectively protect the interest of workers, consumers, competitors and other stakeholders. Digitisation creates new opportunities for all these members of society, but also new threats and both need to be properly addressed.

3.4 Implementing the vision

3.4.1 Objectives for next-generation platforms

Development of new large platforms as such is not required. Instead industry needs targeted demonstrators where manufacturing companies can merge expertise in manufacturing with advanced digital approaches. This will lead to services that where impossible to provide before. Especially demonstrators that connect actors in different Member States are to be encouraged. In line with this priority it is necessary to collect good practices and identify successfully established platforms wherever they are to be found – including those outside Europe - and build on them, rather than seeking to re-invent platforms and opening up new initiatives. This will be the quickest way to reach critical mass.

3.4.2 Definition of supporting initiatives

The proposed approach creates an important role for large-scale federating initiatives. With so many competing initiatives, federation of the more promising initiatives could help to convince industry of the value of digital platforms and would encourage them to develop the accompanying ecosystem. Such initiatives must have clear added value for the constituency concerned and be driven bottom-up (i.e. be voluntary and pre-competitive). Platform definition and use can be and must be orchestrated by administrations but they cannot be enforced by them. It needs to be embraced by industrial users, while research institutions and universities can play important roles in the process of establishing such industry-driven ecosystems. Hence, there is a clear need for an international, inter-sectoral dialogue between public sector and private sector representatives.

3.4.3 An action plan

In many Member States nationally federating initiatives already exist (see overview in 3.2.2). Especially these initiatives should be involved in joint road mapping, together with the PPPs. This collective action should be focused on the development of platforms from small demo-scale to commercially supported ecosystems. Significant attention should be given to supporting the growth of ecosystems. In particular this means bringing together users and suppliers of existing platforms. To this end a number of activities are already foreseen, including “speed dating” events where users can meet suppliers.

3.5 Contributions from PPPs

Both FoF and SPIRE could in principle be involved in setting up digital platforms in a variety of sectors. For example, existing project clusters within FoF could be the basis for a series of digital platforms which together could help realise a true 'plug and produce' approach. Specifically, these are:

- Targeted Innovation Actions, focusing on bringing validation of digital platforms as close as possible to the manufacturing environment
- Research & Innovation Actions that focus on specific challenges such as security, data liability and data analytics

Potential contributions from SPIRE include:

- Towards Cognitive Production: Enhanced digitalisation to implement cognitive production plants for improved performance in the process industries
- Process Decision Making: Integration of life-cycle assessment and costing tools for process decision making
- Towards Industrial Symbiosis: Optimisation of industrial processes based on standardisation

3.6 Contributions from Member States

The outline of national initiatives in section 3.2.2. already showed the significant effort many Member States currently take to work towards Connected Smart Factories. More details about these initiatives are needed to explore how they can match the EU's PPPs and how they can support each other. See also the priorities in section 3.3.3.

4. Overview of the Strategy in "Smart Agriculture"

4.1 Introduction

Smart agriculture offers very significant opportunities for Europe. Applying digital technologies to agriculture holds important promises for most of the challenges the sector is facing. Beyond farming itself, digitisation of the food supply chain has important consequences, including for instance for health care (see chapter 5) and quality of life of Europeans in general. However - as in other areas - currently platform development is fragmented across Europe in this vertical. To maximise potential a clear need exists for a co-ordinated strategy rather than many individual initiatives. To support this a liaison is needed across DGs and Member States, to come up with integrated solutions and an appropriate supporting infrastructure. Currently, there is a lack of awareness of initiatives at Member State level and a list of all projects in the area should be created. This information needs to be disseminated, and to encourage collaboration there is a need for an annual general meeting for the sector to bring key stakeholders together.

Farmers are central to the uptake of the technology. It is therefore crucial that they are intimately involved and are at the centre of development of new platforms. However, reaching them is difficult. Larger farms have a vested interest in adopting technologies, but smaller farms do not have the time or inclination to attend meetings. A different strategy is required to reach these farmers on site. Co-operatives and advisory services could play a vital role to address this.

As in the case of Smart Manufacturing, concepts from the Circular Economy also act as an important driver for digitisation in this area. The notion of the Circular Economy matches well with the resource efficiency that farmers desire in order to be competitive. The farmers are intrinsically driven to produce more with less, addressing concerns about for example minimising water leakage and use of fertiliser. Consequently, opportunities to create greater transparency about how things are produced will be embraced across the sector.

Further sustainability and efficiency improvements can be gained through exploitation of digital platforms. First of all, there is a need for sensors and seamless connectivity. At a basic level there is a need for widespread rollout of Rural Broadband for connectivity. Secondly, a need exists for development of expert systems for optimisation and prediction that farmers can use, e.g. in so-called Precision Farming. Here care needs to be taken not to re-invent the wheel and to provide solutions that meet the needs of both large and small farms.

In order to engage with farmers and developers and promote the use of new technologies there is a need for hands-on experience. The use of Open Living Labs is seen as a very appropriate way to achieve this. Large scale demonstrations are needed to show the benefits of interoperable platforms and the usage of data within smart agriculture. This needs support from Structural Funds from the European Agricultural and Rural Development Fund (EARDF) and the Smart Specialisation Strategy RIS3 to engage with Member States and connect rural development programmes with EU projects. Co-operatives, advisory services and the most relevant parts of the broader agricultural knowledge and innovation systems have a key role to play in connecting at the local level along with Innovation Hubs. Other technology stakeholders e.g. Big Data PPP, FoF PPP, 5G PPP, euROBOTICS and Cyber Security PPP, should also be engaged to address the key issues highlighted by the sector, e.g. interoperability, connectivity, data management and analysis, and security.

4.2 Current landscape of activities

Already some farmers are using a variety of platforms to support and manage their farming activities. At a recent exhibition in Cordoba there was considerable presence of cloud computing and robotics technologies indicating that these are now driving the sector. It was notable, however, that most suppliers in the domain are small start-ups and there is involvement from many regional agencies.

This has led to the creation of many platforms by start-ups, agencies and farmer co-operatives. Sometimes platforms were targeted at single farmers, sometimes they were targeted at groups of farmers, and sometimes at agencies to help with the management of subsidies. Overall, however, development is very fragmented. Typical platforms support farm management for family farms, irrigation, data services, food processing and the management of subsidies.

In the area of robotics farmers are embracing digital technologies for increased automation, e.g. automated feeding and milking systems and automated farm machinery. These are seen as very beneficial as they release time for performing other activities and also allow farmers to spend more time with their families. A number of areas were specifically highlighted:

- **Autonomous Tractors and Combines Harvesters** – Autonomous farm machinery is already commercially available, e.g. from John Deer, and due to the more relaxed safety considerations with respect to traffic it is possible to have much higher levels of automation than is currently possible in the automotive sector. It was noted that uptake of autonomous vehicles within the farming community was still at the early adopter level.
- **Robotic Systems** – Robotic systems are increasingly being used for feeding cattle and for automated milking of cows.
- **Monitoring Systems** – Monitoring systems are being used to monitor the health of livestock to identify illness and also for crop management, e.g. water use.
- **Optimisation for Sustainability and Efficiency** – Sustainability and efficiency are key drivers in the farming industry and this has led to development of software tools to optimise and provide decision support for use of fertilisers, seed sowing and management of fields. Increasingly this is being combined with monitoring systems to provide feedback.

Overall it was noted that the platforms being developed and used are being produced with no coordination, leading to a fragmented offering in the marketplace. Farmers currently have to contend with multiple platforms with little or no interoperability between platforms. This is increasingly becoming an issue and the need for coordinated platform development is growing.

4.2.1 European initiatives

DG AGRI supports a number of activities on smart agriculture, specifically under the EIP-AGRI and H2020. Innovation projects (operational groups) under EIP-AGRI are funded by Member States through Rural Development Programmes. DG AGRI has set up a strategic framework for agricultural research and innovation activities where ICT has an important role to play. An EIP-AGRI Focus Group was set up on Precision Farming that addressed the lack of take up of ICT technologies by farmers. This provided research recommendations and ideas for operational groups to overcome existing barriers for adoption of precision farming technologies.

To promote further digitisation, a seminar on data driven business models was organised by DG AGRI where different models were analysed. In addition a workshop on "Digitising the agri-food sector" had been held to bring together actors from the IT sector (large companies and SMEs) and the Agri-Food sector (farmers and other stakeholders) to analyse current challenges and end-user needs. The aim of this was to identify where emphasis should be placed for the next H2020 WP in the area.

In addition, DG AGRI is preparing a series of events for 2017 related to digitisation in agriculture. Information about these events will be published on the EIP-AGRI website http://ec.europa.eu/eip/agriculture/

The first event on "**Data Sharing: ensuring a fair sharing of digitization benefits in agriculture**" will take place on the 4th and 5th of April, 2017 in Bratislava (Slovakia). During the workshop the existing or potential arrangements, frameworks and pathways to enable effective, fair and valuable

data sharing will be discussed. Therefore, contributing to unlocking the potential the digital revolution holds for agriculture. More information about this event can be found in the following link: https://ec.europa.eu/eip/agriculture/en/content/eip-agri-workshop-%E2%80%98data-sharing-models%E2%80%99

Some European initiatives started in January 2017. BIODATA is a new project funded via the Big Data Value Association which will address data for agricultural applications. The EU is also funding a new IoT Large Scale Pilot called IoF2020. This 4 year pilot with 73 partners will address 19 use cases and 5 trials. Amongst the many real demonstrations in the agri sector there are also aims to promote interoperability and standardisation. The project will exploit many existing platforms and standards such as FIWARE, FIspace, ISOBUS, etc. There are also opportunities for further projects via an Open Call which will distribute 6MEuros. In the robotics sector euROBOTICS is already funding 7 projects in the domain and is planning to set up an Agri Food Lighthouse Project.

4.2.2 Regional and national initiatives

Sustainable agriculture and food safety are driving regional and national initiatives. At that level an increasing interest in data platforms exists, with initiatives being set up in different regions and Member States. For instance, the "Smart precision farming" initiative has been put forward by the Tuscany region of Italy within the framework of the Agri-Food Smart Specialisation Platform. This initiative is in the process of launching and is looking for partner regions around Europe. Likewise in Spain the "Traceability and Big Data" Initiative for the exploitation of data throughout the whole agri-food chain, has also been proposed by the Andalusia region, again within the framework of the Agri-Food Smart Specialisation Platform. This is also in the process of launching and looking for partner regions. The Galician government has set up the PRIMARE Public Procurement of Innovation initiative which is still in the procurement phase. The aim here is to build a regional data platform for capturing and managing of CAP subsidy data. The Spanish Ministry of Agriculture has set up the SIAR Network which is an Agroclimatic information system for the estimation of crop irrigation needs. Already the system has more than 300 sensing stations nation-wide and an open web system for accessing data. This network started building in the early 2000s. There are also other national initiatives such as a university initiative in the Netherlands on precision farming. Notably there is a lack of visibility of initiatives at this level across Europe and it would be beneficial to compile a list across Europe.

Name	**Scope**	**Link**
High-tech farming	Tuscany (Italy)	http://s3platform.jrc.ec.europa.eu/documents/20182/183310/Tuscany.pdf/70146a39-1909-47f9-aa4b-0de1b904fe41
Traceability and big data	Andalusia (Spain)	http://s3platform.jrc.ec.europa.eu/documents/20182/183310/Andalusia.pdf/8950733d-66a0-4771-835d-06092d90c34c
PRIMARE	Galicia (Spain)	http://amtega.xunta.gal/cpti
SIAR Network	Spain	http://eportal.magrama.gob.es/websiar/Inicio.aspx

4.2.3 International initiatives

Large initiatives at the international level are being funded by a mixture of private and public sector funds. Notably the use of data for efficiency, sustainability and business creation is a common factor in these initiatives. The Agricultural Industry Electronics Foundation (AEF) is an alliance of more than 100 companies. It was initially focused on developing the ISOBUS protocol standard for communication between implements, tractors and computers, however, now it also addresses other topics such as Farm Management Information Systems. For sharing data, the Global Open Data for Agriculture and Nutrition (GODAN) initiative is supporting the proactive sharing of open agriculture and nutrition data. Currently there are 400 partners from national governments, non-governmental,

international and private sector organisations in this initiative. For business-to-business (B2B) connectivity FIspace is providing a horizontal collaboration platform based on FIWARE technologies. Already several pilot projects in the agri-food platform have been built using FIspace.

Name	Scope	Link
Agricultural Industry Electronics Foundation (AEF)	Global	http://www.aef-online.org/en/
Global Open Data for Agriculture and Nutrition (GODAN)	Global	http://www.godan.info/
FIspace	EU	https://www.fispace.eu/

4.2.4 Co-operatives

Co-operatives are already actively developing platforms for their members. Many of the data platforms and services for B2B and B2C being produced are closely addressing farmer's immediate needs. An issue is that co-operatives tend not to be connected with European innovation networks while there are lessons that could be learned. An example is the LILA Virtual Community which was launched in 2008. LILA is a company owned by dairy farmers and the dairy industry in the region of Asturias. A platform has been created that shares data about milk analysis results from 2000 farmers in the region. Netfarming, a subsidiary of AGRAVIS (an agricultural trade and services company owned by German co-operatives) has developed the Netfarming Suite of farm management applications for its members. Likewise in France, SMAG has developed a suite of farm management applications for French farmers. SMAG is a company which is part of INVIVO, one of the largest French agricultural co-operatives. Notably in these tools special attention is paid to data ownership aspects.

Name	Scope	Link
LILA Virtual Community	Asturias (Spain)	https://www.lilacv.com
Netfarming	Primarily in Germany	http://www.netfarming.de/
SMAG	Primarily in France	http://www.smag-group.com/en

4.2.5 Commercial

There is a move in the commercial sector to make proprietary systems and architectures more open, so that they are compatible and accessible to third parties. Examples of this are 365FarmNet which is an open platform for linking together applications and services of different manufacturers and service providers. John Deere has now provided an open API for their MyJohnDeere Farm Management Information System to allow access to agricultural machinery data to other systems such as those provided by SMAG and Agro-Office. Similarly New Holland has provided the PLM Connect Farm Management Information and Decision System with an open API.

Although not strictly a "platform", Microsoft's Azure is being increasingly used in commercial products for the agri-food domain and a number of EU companies are offering commercial services for farmers built on Azure cloud services.

Name	Link
365FarmNet	https://www.365farmnet.com/en/
MyJohnDeere	https://myjohndeere.deere.com/
PLM Connect	https://www.plmconnect.com/
Microsoft's Azure	https://azure.microsoft.com/

4.3 Visions for the future

4.3.1 Needs and expectations

The vision for the future is one of increased connectivity and interoperability between platforms. With this it would be possible to provide more services through gathering and combining information from a wide range of smaller platforms gathering data from sensors, machinery, animals, etc. Provision of such platforms would increase resiliency within farming, e.g. managing resource efficiency and managing the health and welfare of animals (i.e. removing sick animals from herds and in transportation of animals), and it could also be used to decrease red tape and bureaucracy which farmers currently contend with. At the same time this would allow farmers to maintain high quality and produce safer products.

This vision places the farmer at the centre of collecting and processing of data. The data can be used internally by the farmer for efficiency and optimisation, but also externally to provide better public services and tools, for instance to mitigate climate change. To enable this farmers need to control access to data from the farm and must also be compensated when others use this data to provide them with an incentive to share. To support this change, farmers will need training and education on how to exploit data. They will also need to understand their rights and responsibilities in a digital world. As "data generators" farmers will have a different role in the value chain. They are more likely to give access to data if they understand how it will be used by external parties. This requires development of trust and partnerships.

The key requirements are for interoperability and standardisation. Farmers need to be able to pick and choose the most appropriate combination of tools from different suppliers. As highlighted in the vision, the farmer needs to be at the centre of the system and thus there is a need for development to be driven by the demand side rather than by the technology providers. Farmers also expect high reliability from equipment as in many cases farm operations are time sensitive. Already it is common for farmers to share expensive equipment via joint ownership of machinery, or call in external companies to harvest or spray a field. Looking to the future the "Uberisation of tractors" is likely to become easier, leading to lower costs and less ownership.

Furthermore, there is a big opportunity to gain benefits through open data sharing amongst farmers. A lot of data collection is still paper based but in the future sensors may be used to automatically collect data. By sharing sensor data the number of installed sensors can be reduced cutting costs for individual farmers. It may also be possible to provide complementary data. Examples of this are the provision of historical yield maps for fertiliser application which can be combined with algorithms and information on the local soil type to control smart spraying machinery. Likewise map information can be used intelligently to irrigate areas based on statistical information or to deposit more seeds in regions of sparse vegetation. An integration and extension of existing benchmarking practices with digital technologies, could provide profound insights in farm management in general, as well as the value of further digitalization of the sector.

Ideally data should be stored in such a way that it can be accessed by different stakeholders. This is already being utilised by business farmer networks in the US. This would allow other companies to create innovative solutions that farmers may buy as add-on services. The business models for this need to be developed, as creating revenue from data is different than from selling hardware to farmers. In the case of data driven revenue generation the model should be subscriber based and needs to be scalable. Barriers to this at present are data ownership and discovering how to create value from data. There are also some legal and technical limitations. In particular, there is a need to protect the ownership of data and maintain the privacy of farm data as well as providing guarantees on the provenance of data. Security of data is also a concern.

For sharing of data in a farmers coalition there is a need to agree on principles for sharing. Potentially this could lead to disruptive business models for coalitions that process and store data and also provide services and training.

4.3.2 Bridging the gaps and addressing the issues

There is a key need for interoperability and standards for connecting platforms. Consensus on platforms and cross sectorial compatibility are needed to achieve this. Although platforms are advertised as sector agnostic this is not true in practice. The requirements for platforms should come from the farmers and the farmer should be at the centre of development. It was noted that in the US farms are large and it is easier to see the benefits from adopting platforms there, as farms are operated more like factories in the US. Within Europe the size of farms differs considerably. There are many smaller farms and here there are different requirements, with a significant market for low cost web services.

Already platform building initiatives and Large Scale Pilots started in January 2017 that will begin to address some of the highlighted issues. A key need is to provide open APIs and provide a platform that is open to all farmers. Demonstration of the efficacy of the technologies is also important to provide confidence. Test regions for smart farming are also needed where new ideas can be tested.

To support this there is a need to combine large scale demonstrators across the EU and link these with activities going on at the national level. These should be used to demonstrate ideas that can be replicated. There is also a need to link with co-operatives at the regional level. However, disparity across regions presents a challenge.

The Common Agricultural Policy generates a significant amount of data, creating an opportunity for the integration with other services and practices requiring similar data. This is typically a case where the already existing data flows are unexploited by the potential other uses and where platforms linking and integrating this kind of data are needed.

4.3.3 Priorities

Four key priorities were highlighted. These are the need for interoperability for connecting machinery and sensors, the need for approaches for data management and handling, the need to address the digital divide and the need to provide connectivity for farmers.

Connecting machinery and sensors.
There have been significant advances in smart tractors and combine harvesters. The farm machinery suppliers often work with the automotive suppliers and the levels of automation used in agriculture is currently ahead of that in use within the automotive sector. This is possible as there is a more controlled environment with an absence of traffic in the field. Already coordinated control of combine harvesters and pick-up tractors exists and is marketed. The original smart tractors provided a plethora of information screens and the farmer had to integrate information in the cab. This has much improved. Likewise interoperable connection of tractors to different implements has been addressed through development of an ISO bus connector between the tractor and a range of add on implements allowing control of equipment. This was led by the Agricultural Electronics Standardisation body to define common interfaces.

Looking to the future the tractor is now becoming part of the cloud and the farm management system. There is thus a need for a new level of interoperability to ensure that all connected systems can all talk to each other. Interoperability standards are thus the focus at the moment.

Addressing the Data Challenge
There is an opportunity for the Big Data Value Association to support the areas of AgriFood, Forestry and Fisheries and produce a Strategic Research Agenda around this. Interoperability is a key requirement and there is a need to provide access to a Big Data stack across different sectors. Here it is possible to gather data from IoT in the field, combine this with earth observation information and also data from farmers associations for instance, satellite imagery, CAP data, GIS information, Eurostat information and weather data. The approach being promoted by the BDVA is to use Innovation Spaces (I-Spaces) that provide a safe environment for experimentation. Solutions providers can access and use this data. This can be linked to national initiatives to explore how value can be created from data in terms of money, jobs, etc. This can be done in partnership with trade associations and projects exploring horizontal platforms. Large scale demonstration of the successful exploitation of data can be used to persuade farmers (usually family businesses) to adopt and trust platforms.

An issue already highlighted is the increasing amounts of data being collected from machinery which is not just used by the farmer. This presents a trust issue. The ownership, access and usage rights for data needs to be clarified. Farmers will only accept this increased data gathering if they are given a fair deal on the data with sufficient control over what data is collected. Security is also an issue with respect to data.

Overall the use of Large Scale Pilots, such as IoF2020 and BIODATA, is considered to be important for demonstrating the benefits of platform interoperability, in particular cost efficiency and sustainability gains. The only concern is how representative these are of smaller farms where the benefits are much smaller and are less clear. At this level it is important to provide things that are easy to use. Notably history shows that more complex systems are not being adopted by smaller farms.

Challenges to overcome in the area of data are provenance and security of data. Ideally platforms and data should be open, because if platforms are closed the benefits of aggregation and analysis of data will be missed. However, there is a need to find the right balance for industry between openness and generating revenue from data.

Addressing the Digital Divide
Most farms are family businesses and there is a lack of digital skills at this level. This means that solutions need to be plug and play and must take into account the needs of farmers. Users thus need to be involved at the design stage. In general farmers are not concerned about technology but are concerned about sustainability and efficiency. There is a need to promote practical experience and this may be possible by supporting linkages with regional co-operatives and providing advisory services to promote digital skills. There is also a need to open APIs and develop trust in digital systems.

Providing Connectivity
Some farmers who live in more remote regions do not have access to an Internet connection and in many places a reliable connection is not present. It is thus important to tackle connectivity to allow digitisation across all of Europe. The uptake of technology depends on this and there is a need to provide a level playing field for all farmers regardless of size, sector and location.

4.4. Implementing the Vision

4.4.1 Objectives for next generation platforms

A key objective is to provide platforms that help farmers optimise fertiliser/pesticide/water usage and quality of their product. There is also a need to support automation of tasks. A challenge is that there are different types and sizes of farms across Europe. Platforms thus need to support diverse needs. For a small farm a smart phone or computer available on a tractor may be used, whereas on a large farm there may be a server. There are now many sensors on a farm and there is a need for interoperability

(in terms of common protocols and data formats). There is also a need for platforms for aggregating data and suitable expert systems to extract insights from the data which the farmer can act upon. It was noted that there are many concerns over data collection and usage. In the first instance data transparency is needed. At the moment farmers are not always aware of which data is being collected and for what purpose. After transparency the next key issue is data ownership. Interoperability and fear of vendor lock-in is another concern. Farmers do not want to be bound to one platform and are looking for plug-and-play freedom to use other platforms.

4.4.2 Definition of supporting initiatives

It was highlighted that farmers are interested in the natural environment, resource management and strategic farm management. Thus platforms need to support these interests. Farmers are increasingly using sensors, robotics and expert systems for managing farms with the aim of global optimisation of farm operations. A Large Scale Pilot deploying digital technologies is needed to demonstrate interoperability across systems at scale. A challenge, however, is that any platform development also needs to meet the needs of both large and small farms across Europe. As highlighted platforms also need to be flexible so that farmers can easily change platforms to avoid vendor lock-in concerns.

4.4.3 An action plan

Farmers are key stakeholders and are central to the uptake of the technology. It is therefore crucial that they are involved in the roll-out of new technology. Reaching them is, however, difficult. Engagement with farmers who are managing larger farms is seen as being easier as they have a more vested interest in adopting technologies. Smaller farms do not have the time or inclination to attend meetings. Here a different strategy is required to reach farmers on site such as via the EPI-AGRI network and via co-operatives.

Although a number of initiatives are highlighted in this report there is a lack of awareness across Europe and also at Member State level of the initiatives that are currently underway. Thus, the most pressing need in the first instance is to create a list of all projects in the area. For dissemination of information and to encourage collaboration it was advocated that there should be an annual general meeting for the sector to bring stakeholders together. DG AGRI is organising a series of events for 2017 in which they will address some of the issues mentioned in this report.

To support the development of the community the Structural Funds for the European Agricultural and Rural Development Fund (EARDF) and Smart Specialisation Strategy RIS3 plans should be mobilised. Notably there is a need to engage with Member States and connect rural development programmes with EU projects.

In terms of technology there is a need for sensors and seamless connectivity in the first instance. There is also a need to provide more widespread rollout of Rural Broadband for connectivity. Following this there is a need for development of expert systems and also predication tools that farmers can use. Here care needs to be taken not to re-invent the wheel. In order to engage with farmers and developers and promote the use of new technologies there is a need for hands-on experience. The use of Open Living Labs is seen as a very appropriate way forward.

There are a number of bodies who can aid in the digital transformation of the farming sector. Co-operatives have a key role to play in connecting at the local level. Other technology stakeholders should also be engaged to address the issues highlighted by the sector, e.g. interoperability, connectivity, data management and analysis, and security. This could involve input from the Big Data PPP, FoF PPP, 5G PPP, euROBOTICS and Cyber Security PPP.

Activities must include the relevant end users. In research and innovation projects this can be achieved via participatory innovation, which is a key principle behind operational groups and multi-actor projects. A successful deployment of digital technologies- and platforms needs to be embedded in the agricultural knowledge and innovation systems of the different Member States and regions. This may involve: clear demonstration of the benefits of digital innovations, training in digital skills to be confident on the use of the new technologies, development of technologies, applications and platforms accessible to all, including small farmers.

4.5 Contributions from PPPs

As highlighted a number of PPPs such as the Big Data PPP, FoF PPP, 5G PPP, euROBOTICS and Cyber Security PPP address issues of key relevance to the farming sector. Each can contribute to building platforms via creating a consensus on cross sectorial platforms. A key need is for them to work together at a European level to support this. Here there is already a BDVA task force addressing the Agri-Food sector. BDVA has recently funded the BIODATA project and is also keen to support activities via European Innovation Spaces which have the aim of providing a place to store data that can be used across borders and sectors. In the area of robotics euROBOTICS already has 7 projects addressing smart farming investigating topics such as drones for gathering data. euROBOTICS is looking to fund a larger scale Agri-Food Lighthouse Project to promote the uptake of robotics in the sector. AIOTI could play a relevant role collaborating with the PPPs primarily through its WG06 on "smart farming and food security", but also through WG03 (standardisation) and WG04 (policies) on the horizontal issues of interoperability and standardization, trust and security. Existing PPPs can contribute to the agri-food platform building efforts in a number of ways. Below some possibilities are highlighted.

PPP	**Action Line**
Big Data PPP	Apply the Innovation Spaces (I-Spaces) approach to the farming sector, for providing experimentation environments that can help to understand more clearly the benefits of big data in agriculture, thus accelerating its adoption.
Factories of the Future PPP	Agri-food industries could play a relevant role as a vertical sector in the FoF PPP. The food and drink industry, according to Eurostat, is the largest manufacturing sector in EU. Prioritising this sector in the SRIA of the FoF PPP would guarantee a positive impact in EU economy.
5G PPP	Inclusion of agriculture as a priority vertical sector for the 5G PPP would help to ensure that future connectivity requirements for farming applications are properly met (the number of IoT devices/sensors in rural areas will need to increase)
Cyber Security PPP	Inclusion of agriculture as a priority vertical sector would pose use cases that in turn would act as drivers of security technologies for improving platform trust and data security, including sharing, ownership and provenance

4.6 Contributions from the Member States

It was noted that there are different priorities in different European regions, e.g. pesticides are less of an issue in Eastern Europe. The Member States, however, can facilitate technology take-up through public investments of Structural Funds or via strategic use of other funding sources. The EARDF (European Agricultural Fund for Rural Development) implements the Common Agricultural Policy 2014-2020 (CAP) and part of this must be invested in innovation for enhancing the competitiveness of the primary sector. Such funds are managed by regional or national authorities, who design and implement investment programmes. In regions which have identified agri-food priorities in their Smart Specialization Strategies (RIS3 plans), measures can also be supported by ERDF funds

(European Regional Development Fund) implementing Public Procurement of Innovation (PPI) initiatives. At a regional level Innovation Hubs are needed. Living labs are also seen as useful for testing sensors and ideas. Accelerators/incubators at a local level also provide a mechanism where SMEs can try out sensors, hardware and ideas. Overall there is a need for linkages between national initiatives, particularly considering sustainability and rural development. A key requirement to achieve this is to engage with national ministries and regional centres.

5. Overview of the Strategy in "Digital Transformation of Health and Care"

5.1 Introduction

In the past decades, remarkable progress has been made in terms of increased health, partly as a result of improved treatment options and access to high quality health care. These successes have not only increased longevity and health of populations, but also contributed to productivity and prosperity. Nevertheless, as a consequence of demographic changes and progress in medicine, European Member States (and the world) face an increasing challenge with regard to sustainable provision of high quality health and care to citizens. Public expenditure on health care and long-term care accounted for 8.7% of GDP and about 15% of total government expenditure in the EU in 2015. The ageing population and prevalence of chronic diseases is estimated to increase public health and care budgets significantly in the next decades. The challenge we are facing in the domain of Health and Care consists of the following three main elements.

First, as a result of substantial advances in molecular biology, computer science, micro-electronics, radio physics and many other fields, health care's influence on the average individual's walk of life has significantly increased in the past half-century. Consequently, indicators of health such as (healthy) life expectancy have soared. In Europe, life expectancy currently increases with "one weekend per week". Partly due to the advances in medical technology opportunities for a growing influence of (preventive) health care on our lives continues and even accelerates. We are becoming older and are ageing more healthily than ever before. (Minimally invasive) interventions that were unimaginable even 10 years ago are now commoditized in peripheral hospitals and accessible to many. Further improvements are foreseen. However, at the same time, it is clear that we could do even better.

Avoidable mortality and morbidity remain large. An epidemiological transition from communicable diseases to non-communicable diseases is an important driver of morbidity and mortality. Hence, more fully exploiting the health potential of individuals, especially those in vulnerable socio-economic groups, remains of great importance. A shift currently takes place in healthcare from symptomatic treatment of (acute) diseases by blockbusters towards Predictive, Preventive, Personalized, Participatory and Precision medicine that will offer new opportunities for patients and the healthcare systems in Europe.

Secondly, the increased sophistication of curative care, relying on more accurate but often also more expensive new technology, has caused a strong rise in the costs of health care besides delivering the increased benefits already mentioned above. Furthermore, the rapidly ageing population that results from better public health increases the need for (labour intensive) long-term care, which also causes costs to rise significantly. The shortage of labour supply in health and caring services in Europe is estimated to reach 20 million people by 2025. Moreover, insurance systems tend to reward health care providers for performing more activities, instead of rewarding them for working more efficiently. At the same time health care consumers, with increasing demands and expectations, typically receive limited encouragement to require less care, e.g. by engaging in preventive action where possible. Several other important reasons for rising health care costs exist. Without mitigating efforts those causes will persist. As a result, without effective action health care costs may become unsustainable, when they are allowed to account for a large and increasing share of GDP.

Finally, despite the increased inclusiveness of health care, health is far from evenly distributed across the population. For years the World Health Organization (WHO) has stressed that health inequity, i.e.

unfair, unjust and avoidable causes of ill health, continues to kill people on a grand scale[14]. It is obvious that health inequity exists when considered at a global scale, in a comparison between countries. However, it also applies to differences inside countries (including EU Member States), to the point where even within one city life expectancy can differ by a decade or more, depending on the neighbourhood. Socio-economic status is important in this context. According to the WHO the "social gradient", i.e. the link between income and health, is a universal phenomenon. The differences in health tend to become larger rather than smaller, because the "(health)haves" tend to benefit most from new knowledge and technological opportunities. Addressing this social gradient is key in an EU that strives to be inclusive.

Digital technologies such as Big Data, IoT, robotics, Artificial Intelligence (AI) or High Performance Computing offer new opportunities to address these challenges. They can radically transform health and care systems and delivery, enabling new approaches to prevention, personalised medicine, access to integrated health care and independent living.

Personalised medicine, enabled by vast amounts of data from various sources, marks a real paradigm shift. Throughout their own life cycle individuals become more central, not only as recipients of care, but also as more informed and empowered players in their own health and living. They can access and manage their personal health records, decide to participate in "data donation" for the greater good, and rebalance their relationship with doctors[15]. Digitisation can also help to provide technologies that improve prevention and can assist in nudging[16] towards healthy behaviour.

Digitisation opens up new frontiers for research as well, as large data sets can be analysed to push the borders of knowledge further, such as in the Human Brain Project. There are new opportunities for medical equipment manufacturers, to meet demand for sophisticated technology for healthcare providers (e.g. scanners, such as those for fMRI). Mass-market demand is emerging for user-friendly mobile devices and fitness or healthy ageing solutions in the home environments.

Digitisation can thus contribute to more efficient health care delivery and to fairer and stronger health systems around the globe. One obvious example is the streamlining of the exchange of medical data between health care providers. Consequently, digitisation can support more health achieved by given budgets, i.e. health care that is increasingly value-based. Finally, digitisation can also help to increase the equity of health, e.g. by improving access to health care.

5.2 Current landscape of activities

As in some other areas described in the other chapters of this report the digital disruption as outlined above has already arrived to some extent in the domain of Health and Care. This transition is to a large extent driven by an explosion of available data. Advanced data analytics open new possibilities for personalised, predictive, preventive and participatory medicine, for efficient continued and integrated care, and for attractive wellbeing products and services, as illustrated in Figure 5 below.

On this basis new prospects are envisaged by the pharmaceutical industry. They expect to shorten the cycle of drug development (including through "in silico" trials), while designing medicines, and monitoring their impact in a much more targeted way (pharma increasingly positions itself as a "data industry"). In Europe, health is already a major industrial sector in its own right (around 10% of EU GDP) and the prospects of massive digitisation open big opportunities for further expansion.

[14] http://apps.who.int/iris/bitstream/10665/69832/1/WHO_IER_CSDH_08.1_eng.pdf
[15] Prahalad, C.K. and Krishnan, "The new age of innovation". McGrawHill, 2008.
[16] Thaler, Richard and Sunstein, Cass. "Nudge: Improving Decisions about Health, Wealth and Happiness". Yale University Press. 2008.

Consequently, there is much more at stake than just transforming health data into digital formats to facilitate data storage, exchange and analysis. The changes under way towards "Health 4.0" are a significant part of the wider transformation of digitisation including developments like Industry 4.0 and the agendas for Smart Cities agendas. Health and Care will constitute a major part of the data economy. This domain offers significant market opportunities for large and smaller European companies if one considers that the European home health and care market is estimated to be worth 57 B€ by 2017. It can be a source of new jobs in healthcare, industry and academia.

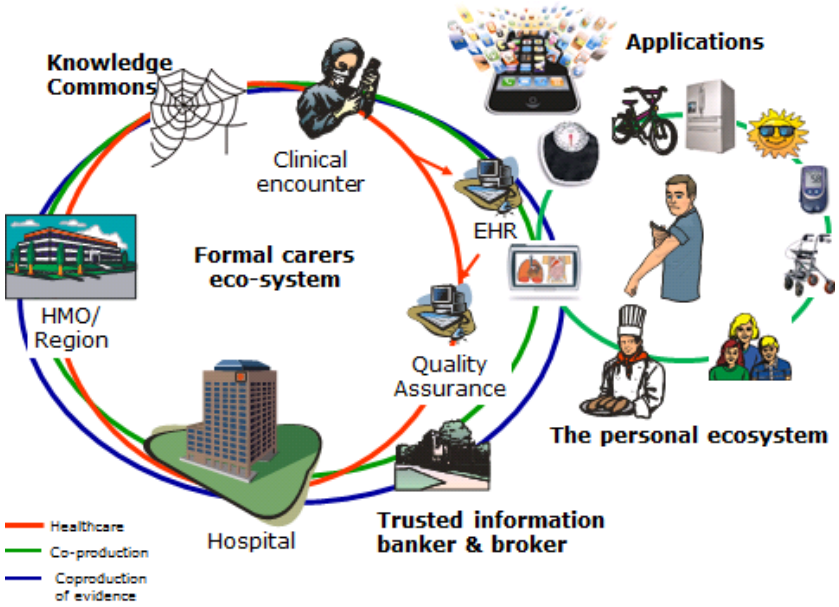


Figure 5: Integrated Personalized medicine

However, a big gap still remains between the potential of digital transformation and the realities of health and care systems today. For example, many restrictions to the movements of health data exist (even concerning the exchange of data between nearby hospitals). While these restrictions can sometimes be understood, e.g. from the point of view of privacy protection, they are not always justified and sensible. As a result of these constraints, legacy health and care systems often remain fragmented and innovate relatively slowly, despite the existing opportunities. Major impact will only become possible if the right incentives and conditions are in place, notably for data management and sharing (e.g. data integrity, confidentiality, security, interoperability, portability, ownership, liability…). See also chapter 6 for a more general discussion of these issues.

5.2.1 European initiatives

Current activities of DG CNECT targeting digital innovation for health and social care include:

- Research and innovation under Horizon2020-Societal Challenge 1 (Health, Demographic Change and Wellbeing) with a budget of more than 1B€;
- Research and innovation under Horizon2020-LEIT and FP7 relating to Micro-Nano-Bio Systems (MNBS) regrouping more than 100 projects with about 500M€ EU funding
- The Active and Assisted Living Programme with Member States;
- The EIT-KIC on healthy living and active ageing;
- The European Innovation Partnership on Active and Healthy Ageing (EIP on AHA) co-managed with DG SANTE and DG RTD;

- The eHealth Action Plan[17];
- The Joint Programming Initiative with Member States on More Years –Better Lives
- The EU Silver Economy strategy.

The work on Micro-Nano-Bio Systems has been driven by both technology offer and user/market demand for about 15 years. The portfolio analysis showed a clear trend towards (i) higher levels of integration of building blocks/functionalities and (ii) increased portability and wearability of systems for measuring/monitoring at the point of need, thus avoiding expensive and time-consuming laboratory-based tests. Proven concepts and functional prototypes exist with the potential to create new opportunities to improve our healthcare systems, in particular personalized or precision medicine, food safety, environmental monitoring and security. Nevertheless, most of them need reliability testing and validation in real life environments.

Other EU policy and funding activities and priorities within the LEIT part of H2020 that are relevant and can benefit from further synergy include IoT, Smart Homes and mobility, Big Data, Inclusion, Industry 4.0 and Robotics. Technology platform of construction industries (DG GROW), medical devices (DG GROW), health technology assessment, cross border care and performance of health systems (DG SANTE), long term care and labour inclusion (DG EMPL), smart specialisation strategies (DG REGIO), innovation for health and ageing (DG RTD, JRC).

See Figure 6 for a schematic representation of the Horizon2020-Societal Challenge 1 initiatives.

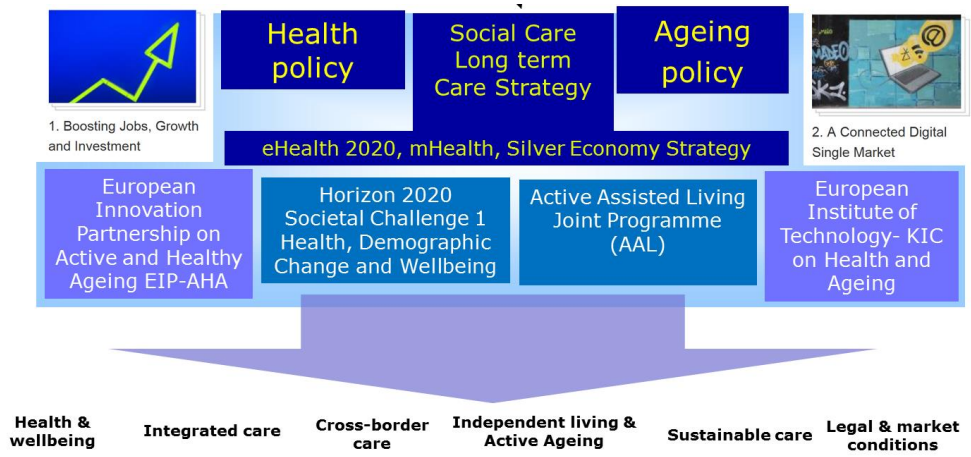


Figure 6: Examples of EU initiatives in the domain of Health and Care

Only a few examples of projects and initiatives can be given here in relation to Figure 6.

ACTIVAGE (2017-2020) is a Multi Centric Large Scale Pilot on Smart Living Environments. The main objective is to build the first European IoT ecosystem across 9 Deployment Sites (DS) in seven European countries, reusing and scaling up underlying open and proprietary IoT platforms, technologies and standards, and integrating new interfaces needed to provide interoperability across these heterogeneous platforms, that will enable the deployment and operation at large scale of Active & Healthy Ageing IoT based solutions and services, supporting and extending the independent living of older adults in their living environments, and responding to real needs of caregivers, service providers and public authorities.

The main goal of the universAAL project is to make it easier for the ICT industry in Europe to develop and successfully deploy solutions for Ambient Assisted Living (AAL). To achieve this, the

[17] See https://ec.europa.eu/digital-single-market/en/news/ehealth-action-plan-2012-2020-innovative-healthcare-21st-century

project is developing an open standardized platform/specification on which the AAL service providers can quickly and cheaply build AAL services. The project also assists the developers by providing development tools to further decrease the development costs. Moreover, UniversAAL helps to further expand the AAL market by providing an application store, called uStore, through which developers, service providers and end users can offer and obtain AAL applications.

AEGLE (2015-2018) will build an innovative ICT solution addressing the whole data value chain for health based on: cloud computing enabling dynamic resource allocation, HPC infrastructures for computational acceleration and advanced visualization techniques. It thus addresses the big health landscape characterized by large volume, versatility and velocity (3Vs) which has led to the evolution of the informatics in the big biodata domain. It also takes into account that data generated in the health domain is coming from heterogeneous, multi-modal, multi-lingual, dynamic and rapidly evolving medical technologies.

The EIT launched the EIT on Health and Aging, devoted to entrepreneurship and innovation regarding healthy living and active ageing in December 2014. Headquartered in Munich EIT Health has co-locations in London, Paris, Heidelberg, Barcelona, Stockholm and Rotterdam and brings together nearly 100 partner organizations.

5.2.2 National and regional initiatives

In line with the developments outlined in this chapter's introduction the health care industry is growing in many Member States. In Germany it is already one of the largest, most successful and most diverse industrial sectors. Many Member States have taken initiatives to federate their R&D and business development in this domain. One example is the Top Sector initiative Health in the Netherlands. 93% of WHO European Member States (42 countries) have made public funding available for e-Health programmes, showing the strong commitment of governments for further development in the sector.

Health analytics and Big Data hold significant potential for health, but this potential is not being explored rapidly enough. Few policies are available to support progress in this area. Currently, only 6 countries have a national policy or strategy regulating the use of Big Data in the health sector.

80% of Member States have legislation to protect the privacy of individual health-related data in electronic health records – an increase of nearly 30% since 2009. This indicates significant progress in adopting electronic health records responsibly.

73% of WHO European Member States (33 countries) do not have an entity that is responsible for the regulatory oversight of mobile health apps for quality, safety and reliability, despite widespread use of such technology.

38% of WHO European Member States (17 countries) have yet to establish a dedicated telehealth policy or strategy.

Several regional initiatives exist as well. Some examples are the following:

Some 45.000 senior citizens currently benefit from ICT-enabled telecare services integrated with Community Care across Scotland. This has led to record improvements in the perception of safety and wellbeing by the targeted population, and saved the national health and care systems over €90 million in 5 years.

Northern Ireland's NHSCT (Northern Health and Social Care Trust) launched an innovative ICT-enabled integrated medicines' optimisation programme (MOIC) covering over 400.000 people. The

innovative solution was designed to reduce adverse incidents with medicines especially amongst the ageing population. The programme resulted in 10% fall of hospital admissions due to adverse drug events and savings of £60 million in terms of bed days. It resulted in efficiencies of £48 per month per patient. Thanks to the EIP on AHA this programme is now being replicated across Northern Ireland and 3 regions: Lund (Sweden), Tallaght (Southern Ireland) and Central Norway.

The Andalusian strategy on Active Ageing emerged from the EIP on AHA targets and focuses on all 65+ citizens in the region aiming to improve their social welfare by integrating policies on living safely, healthy living, participation, contribution and innovation, and lifelong learning. The initiative has contributed to the creation of 322 non-profit organizations and over 2600 jobs.

The region of Southern Denmark develops new solutions in health by closer integration of hospitals, universities and businesses. The regional smart specialisation strategy inspired by the EIP on AHA has identified health and innovation as one of the priorities, and is linked to a comprehensive growth model. This has resulted in 776 additional jobs in the period 2012-2013, as well as a positive impact on the turnover of companies estimated to be in the region of Dkr 3,7 billion.

Within the EIP-AHA, 74 regions and initiatives have been awarded status of Innovation Reference Sites based on their local initiatives in health and care innovation.[18]

Finally, several large industrial companies have embraced the domain of health and care as (one of) their core market(s). For instance, Philips has developed a platform dedicated to health care (HealthSuite) and Siemens has also invested substantially in the strengthening of its position as a provider of medical technology.

5.2.3 International initiatives

In the US many complain that while costs for health care have increased sharply, the health care system is actually delivering less (results) for more (costs). Digitisation is embraced as an opportunity to change this and initiatives for eHealth can be found across the country, such as the Massachusetts Digital Health Cluster (which includes world class universities in the Boston area and 13 of the top-100 Health Technology firms in the country).

5.3 Visions for the future

5.3.1 Needs and expectations

Whilst the many current EU and national/regional initiatives are important and complementary, there is a lack of an overarching strategy as to how some of these initiatives can interact and create stronger synergies amongst themselves. A coherent vision will also require a new model for linking up different EU initiatives, with clear industry commitments as well as support from Member States and Regional strategies.

Accordingly, stakeholders in this area support the overall WG2 recommendation for experimentation and bottom-up integration and for interoperability and connectivity that was already outlined in general terms in chapter 2. In addition, to specifically use digitisation to address the challenges in Health and Care outlined in section 5.1, the following needs were identified.

To achieve patient-centric healthcare and improve efficiency in prevention, diagnosis and care at the point of need, advanced digital technologies such as robotics, cyber/physical systems, micro-electronics, photonics and artificial intelligence, combined with new discoveries in life sciences, need

[18] See https://ec.europa.eu/eip/ageing/reference-sites_en

to be fully integrated, tested and demonstrated in real life. Furthermore, the emergence of open platforms/open environments and big data will enable the provision of innovative health and care solutions in homes, health centres and hospitals. Indeed, the improvements offered by the massive deployment of digital data technologies in the management, aggregation, analysis and contextualisation of medical data (including human genotype and phenotype data) and the possibility to build bio-medical models with virtual reality tools for diagnosis, therapy planning or education, is unprecedented. This in turn will trigger innovation, new business models and opportunities for many SMEs in the healthcare/e-health sector.

One example to illustrate the new possibilities but also the complexity of the new medical options are smart wearable or implantable devices, for providing therapeutic treatments and monitoring their effect. For example, in cardiac rhythm management or neuromodulation, beyond existing products, integrated solutions are needed, which can sense various electrophysiological stimuli, biomarkers or other health indicators (dehydration, stress, BMI, muscle fatigue, balance etc.) as well as the therapeutic products themselves. Integrated signal processing algorithms will be needed to monitor and alert for significant physiological changes as a means of monitoring disease, as well as providing feedback on the efficacy of a treatment programme. These systems will communicate with relevant electronic medical record (EMR) systems and prompt action by healthcare professionals as applicable based on sophisticated algorithms designed to identify patterns or ranges of concern (i.e. using data analysis and IT communication tools to inform unambiguously clinical decision protocols). These smart wearable and implantable systems will therefore require multi-Key Enabling Technologies (KET) capabilities, involving integration of micro- and nanoelectronics, microsystems, photonics, likely including integrated circuits for miniaturisation and power efficiency, energy harvesting and storage technology, advanced sensors, embedded software for signal processing, safe and secure RFID and wireless connectivity, data encryption, and communication to EMR system. They will also require biocompatible packaging (advanced materials) and encapsulation, and need to combine precision engineering and electronic/photonic assembly.

Trends such as these translate to an urgent need to support cross-disciplinary research and the development and clinical validation of lab-proven medtech technologies and prototypes in several healthcare applications. Technologists and clinicians/healthcare practitioners will need to closely cooperate to deliver solutions at the point of need whether at the hospital (e.g. to support logistics, surgery and image guided intervention) or at the primary care and in remote settings (e.g. companion diagnostics, health monitoring, e-health).

Furthermore, in the domain of Health and Care it is expected to be more difficult to go beyond national platforms than in other areas, as each country has its own specific regulations and usually stringent constraints concerning the use of medical data. In this area in particular issues concerning ethics and privacy need to be carefully taken into account, preferably at an international level. Furthermore it is expected that within the health domain several platforms and ecosystems will develop and grow around specific aspects of the health care value chain, e.g. for imaging, telemonitoring, teleconsultation and genomics.

5.3.2 Bridging the gaps and addressing the issues

In December 2015 at the 4th Conference of Partners of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA), European Commissioner Günther Oettinger (Digital Economy and Society) outlined how digital innovation, enabled by a functioning Digital Single Market, can transform demographic change and the growing number of chronic health conditions into an opportunity for Europe's economy and society. Commissioner Oettinger invited all stakeholders to work together with the European Commission in the development of a blueprint. A "shared vision" on how innovation enabled by a Digital Single Market can transform Europe's ageing society in the 21st Century and contribute to the European Silver Economy (keynote speech - 9th December 2015).

Recognising that a shared vision is essential to mobilise investment and guarantee the commitment of all actors to this digital transformation of health and care for the ageing society, a number of industrial players, regional authorities, professional organisations and multistakeholder platforms such as the EIP on AHA have accepted the invitation from Commissioner Oettinger and have developed a first version of this blueprint. The Blueprint was handed over to Commissioner Oettinger during the 2016 European Innovation Summit on Active and Healthy Ageing in Brussels on 7th December 2016. This includes a commitment to spend more than 4B€ in procurement of innovation solutions for health and ageing from the 72 Reference Sites of the EIP-AHA and to demonstrate the returns of investment from innovation by providing new services to more than 4 million citizens by 2018.

The Blueprint is a means to "*connect the dots*" of a very complex landscape on digital health and social care and active and healthy ageing. The Blueprint can create an overarching "political vision" that is aligned with the major priorities of the Juncker Commission (notably on promoting Economic Growth and Jobs, and realising the Digital Single Market). This vision is a necessary pre-requisite to set a clear political agenda across the European Union and harness resources to act, particularly as results are not likely to come overnight and fall within short-term political cycles at regional, national and European levels. The Blueprint will serve as a mechanism to raise awareness about the potential of better care coordination amongst the large community of relevant stakeholders, including users. The Blueprint will also rely on some of the important methodology tools currently available (*especially those originated by the EIP-AHA partners*) to assess their readiness to integrate services supported by digital services.

The DEI initiative can build on this and contribute to taking this vision forward in order to overcome innovation barriers and to reach scale and critical mass in Digital Transformation of Health and Care in Europe for the benefit of citizens, for improved sustainability of health and care systems and in order to create new markets and growth for industry in digitally enabled health and care. Against this background, potential areas for digitisation in health care that have been discussed by the WG are:

- Trusted Big Data solutions and cybersecurity for health and care (see chapter 6 for more details);
- Deployment of robotics, AI and autonomous systems for health care;
- Enabling cross-cutting technologies, e.g. micro/nano biosystems, bio-photonics, wearables, IoT, to address healthcare at the point of need (see chapter 7 for more details), especially in remote and low resources settings.

Regarding robotics, AI and autonomous systems the primary objectives are to further develop, integrate and demonstrate solutions for:

- Providing better delivery of care, diagnosis and treatment, lower risk and improved information and monitoring that delivers the right treatment to the right person at the right time in a minimally invasive and focused way (e.g. endoscopic wireless capsules with sensing, vision and biopsy capabilities, AI-assisted diagnosis).
- Improving the operation of the health systems (e.g. by lowering costs, delivering higher quality of service with less variation across Europe, better utilisation of resources, more efficient movement of goods and services, and better knowledge to support decision making) through robots and autonomous intelligent systems that support hospital personnel (in addition to conventional logistics).
- Improving the quality of working life/environment for hospital staff: better safety, lower risk, fewer accidents at work, better support, allowing them to deliver a better quality of care e.g. for doctors (e.g. the robot as a dedicated tool in psychiatry), nurses (e.g. helping lifting patients) and medical assistants (robotic, friendly presence in corridor for ill kids).
- Addressing health care's current and future challenges (access, costs, demands, quality) by developing innovative solutions, technologies and processes. Mobilising interdisciplinary efforts and all relevant stakeholders through the whole value chain. Providing Europe with the world

leading health system and supply industry. Improve the quality of life for European citizens (ex: social robots supporting elderly at home or at the point of need).

Initiatives should aim at demonstrating how health systems and robotics empowered with artificial intelligence capabilities can be integrated to provide more robust, highly autonomous, personalised and collaborative quality and cost-efficient healthcare. The provision of pilots, demonstrators, platforms and standards is essential for integration. Projects will target health systems improvements, physical logistics, personalised treatment, data privacy and analysis, infrastructure, certification and validation. Critical to success will be the engagement of centres of excellence, innovation hubs and pilot sites. Projects must attract private and national investment to reach the long term goals; this cannot be achieved by funding from the EU alone.

Regarding enabling cross-cutting technologies, opportunities exist with regard to better understanding of the origin and the expression of diseases. When supported by technologies that are capable of detecting pre-disposition to disease conditions or earliest possible signatures of emerging disease, the possibility of providing immediate, specific and highly targeted intervention will revolutionize the healthcare landscape. Today, several well performing prototype systems and solutions have been developed, with great potential to meet these challenges in the short to mid-term. They are at the level of full integration and/or at lab testing level (e.g. new diagnostic devices, smart implants, lab-on-chip for cancer detection, drug delivery and wearable monitoring systems). These smart integrated systems, which are often highly connected and often operate outside traditional healthcare settings, result from research efforts at the interface of key enabling technologies (e.g. micro-nano electronics, photonics, nanotechnologies and biotechnologies) and are able to intervene and monitor phenomena from macro to micro or nano scale (e.g. from organ/tissue to cells, molecules, genes). They have the potential to be used by professionals and consumers and disrupt existing solutions. However, the penetration to the market is slow and many advanced prototypes remain at the laboratory level or fail in real subjects/samples. Current solutions at the level of proof-of-concept have to be validated in traditional settings before both the consumers and regulators feel confident enough to enable the widespread adoption.

Hence, the main objective of initiatives related to the adoption of cross-cutting technologies is to accelerate the translation of lab-proven bio electronics, photonic and nano-medicine systems to the healthcare market by providing technology and product developers with a one-stop-shop access to a full range of required expertise, capabilities and infrastructure for:

- Validation and testing in a real application environments;
- Pre-clinical and clinical testing, prototyping;
- Pilot manufacturing (in appropriate volume for clinical testing);
- Health technology assessment, business development, market intelligence, access to finance;
- Regulation, certification, ethics and data protection and reimbursement issues.

Projects in this area must play a strong role in joining up the full ecosystem, in particular the medtech device supply chain (including the ESTHER initiative), public authorities including HTA, social security and end-users, including the eHealth network, the eHealth stakeholders group and the EIP on AHA.

5.3.3 Priorities

WG2 recommended the following priorities:

Develop a world-leading health and care research and innovation infrastructure
This could build on the European Cloud Initiative and European Open Science Cloud, by providing access to large scale datasets, longitudinal data and a High Performance Computing infrastructure with simulation and advanced computer models required for development of predictive and

personalised medicine. Existing efforts from industry and academia should be federated to realize this, with a strong research focus while also seeking business exploitation. Ongoing and planned research activities supported by H2020 in the area of technologies and health should be linked to this cloud initiative.

The further development of advanced testing infrastructures should be stimulated, where new ideas for digitally enabled products and services for improved health and care can be tried in realistic environments with end-users, in order to validate the benefits and societal impacts. This should include hospitals, health and care settings and smart living environments and homes. This can build on a number of ICT PPPs, smart and age-friendly cities, European and national/regional living labs, 5G testbeds, in order to stimulate innovative new products and services for improved health and care.

Support for large scale market creation of digitally-enabled products and services for health and care

A European priority roadmap for scaling up deployment should be developed, with a timeline for commitments for large scale deployment of innovative products and services, with relevant demand and supply side stakeholders in health and care, including some those active in the EIP-AHA, following on the process initiated with the Blueprint for digital transformation of health and care.

This could be supported by large-scale pilots for market testing of digital solutions in priority areas of health and care, supported by Horizon 2020. This can in the short time frame build on the newly launched H2020 LEIT-SC1 large scale IoT pilot on age-friendly and smart living environments, as well as big data pilots for health applications currently funded under H2020. mHealth pilots could be launched as well, further to the recently adopted privacy code of conduct on mHealth apps, and ongoing work on medical validity of data from mHealth apps. All these pilots should be linked to policy priorities, e.g. the data generated would be dealt with according to the recommended principles and would feed the health cloud initiative. These initiatives should also provide a strong socio-economic evidence base to monitor and feed the future policy in the domain.

Moreover, significant support from the European Structural and Investment Funds is already devoted to health and care, including its digital aspects. Further mapping and support should be developed in order to have a better view on what has been done so far and what more can be done in the future, e.g. through regional innovation "twinning schemes".

Improving enabling conditions

Mobile devices, modern care institutions, smart homes and living environments – enabled by sensors and connected devices, in a context of IoT and cloud computing – generate an enormous amount of exogenous health and lifestyle data. These technologies, and the data they generate, are at the core of connected hospitals, monitoring of patients while they are at a distance and on the move, independent living solutions and age-friendly housing. However, rolling out innovative, technology-enabled, approaches is challenging as a result of fragmented market forces, national legislations and uncertainty linked to issues such as data ownership, liability, re-use and sharing. Indeed, today there are many restrictions to health data access and sharing, as well as uncertainty about ownership and liability for adverse outcomes further to decisions taken, or not taken, based on that data.

Big Data in healthcare is overwhelming because of its volume and the diversity of data types and the speed at which it must be managed. Therefore, in addition to the issue of access to data it is important to adequately address issues of data storage and processing. The criteria include availability, continuity, ease of use, scalability, ability to manipulate at different levels of granularity, privacy and security enablement, and quality assurance. Real-time big data analytics is a key requirement in healthcare as it can significantly improve understanding of disease management and give new insights in clinical effects of medical procedures and medicines. The lag between data collection and processing has to be addressed. The European Open Science Cloud, Free Flow of Data Initiative and High Performance Computing support these aspects of data management.

Individuals should be able to access, use and share their data. The aim is to allow them to have greater control over data about their health and lives, including the possibility to donate or trade with the data, also across borders. Portability of health and lifestyle data collected in smart homes or other environments would enable innovative services for individuals and new business models. It would also facilitate public health services and health-related research. Not all such data are per se personal data, notably data generated by home appliances, by the lighting system etc. Identifiers linking the data to the person living in a smart home or other environment can be taken away and re-identification, e.g. through recognition of specific usage patterns of home appliances that identify an individual person, can be made impossible.

Following up on the upcoming data Communication (January 2017) and possible consultation, there should be a further analysis of the restrictions and uncertainties concerning health-relevant data, in view of providing legal guidance and addressing unjustified barriers. This analysis could also address issues of liability for harm caused by data captured by devices and sensors, and possibly go beyond machine-generated data. Guidance on health data may range from a fresh legal orientation on health data (e.g. in light of possible legislation on free flow of data) to interpretation of existing legislation (General Data Protection Regulation, medical devices, clinical trials...). Such legal guidance would aim at tackling unjustified restrictions and fragmentation, while promoting certain principles: minimal localisation restrictions, FFD, portability, individuals must be the owners of their health data, etc.

Specific guidance on data donorship should be provided to identify major sources of health and care related data and help mobilise systemic donorship and conditions for their use, accompanied by reference implementations.

Moreover, work should continue on interoperability and standards for eHealth and smart living solutions, as foreseen in the DEI initiative.

Relevant European legislation and policy includes the cross-border care Directive (notably activities on interoperability of electronic health records and electronic prescriptions, supported by the CEF), European Reference Networks for rare diseases, pharmacovigilance system, etc.

5.4 Implementing the vision

In order to fulfil the proposed vision, there is a need for an ambitious large scale European initiative on “Health 4.0” which would address the priorities listed above and could inform the development of future national and European research and innovation priorities beyond H2020, from basic and applied research, to innovation and large scale deployment. Research efforts should aim at faster translation into interoperable digital solutions and services with a high impact. See Figure 7 for a schematic representation.

Figure 7: Health 4.0 components

This could build on existing relevant EU initiatives such as the "Active and Assisted Living joint Programme", the Joint programming initiative "More Years Better Lives" and the EIT on Health and Ageing as well as a number of industry PPPs and Joint Technology undertakings.

5.4.1 Objectives for the next generation platforms

Personalised tools and services for tailored management of health, care and wellbeing will aim at early prediction and prevention of diseases, as well as avoidance of unnecessary institutionalisation. They will also promote prolonged independent living for an ageing population. Advancements in understanding disease and behaviours will allow discovery of efficient biomedical products, a safer medicine and a better quality of life in all the environments (home, work, healthcare institutions). The goal is also to make Europe a global market leader in transformative digital solutions for health and care by supporting demand and supply side stakeholders in piloting, procuring and testing promising ideas in realistic environments across Europe. The aim is to provide scalable solutions ready for large scale market uptake, including socio-economic evidence of impacts.

Thus, as in the other areas, much attention should be given to connectivity and interoperability of platforms in this domain. Opportunities to deploy platforms that were not specifically designed for the health sector should also be considered. Co-creation of an ecosystem of digital propositions and integral solutions on a cloud based platform that is open, secure, collaborative should be emphasized.

5.4.2. Definition of supporting initiatives

A set of supporting activities are already under way within the DSM, Blueprint, the EIP-AHA and through the eHealth Action plan, but should be further enhanced with support from relevant PPPs, JTIs, EIT KIC Health, AAL Joint Programme, and others.

ECSEL's 2017 Multi-annual Research and Innovation Agenda (MASRIA) provides an entry point for creating an open digital health platform ecosystem, enabling cost effective development and validation of healthcare appliances and applications. The platform should provide an open environment, enabling a wide range of collaboration opportunities and easy market access for new applications. The platform is supposed to be open for new appliances and applications by providing API's (Application Programming Interfaces), while taking safety, security and privacy into account.

5.4.3 An action plan

The acceleration of the introduction of robotics, IoT, Big Data, AI and cross-KETs as cost-effective technologies into the healthcare system large pilot projects should be established, in order to demonstrate added value to for instance medical diagnostics, surgical procedures, clinical services, prosthetics, rehabilitative care, smart hospitals, healthy living and active ageing or age-friendly housing. Regulatory and legislative aspects of the use of the platforms should receive specific attention, especially considering privacy regulations. The action plan should reflect the following:

- Build on the Blueprint for digital transformation of health and care in Europe, which has already established an outline action plan for reaching first targets by 2018;
- Launch a set of large scale pilots to address key areas of interest as outlined in this chapter, building on the Horizon 2020 workplan 2018-2020;
- Build a platform for all relevant stakeholders to define a strategic research and innovation agenda, facilitate networking, define new business models, specify standards and provide training;
- Provide specific support to SMEs, through information and guidance, clustering and benchmarking.

5.5 Contributions from PPPs

The stakeholders in WG2 consider PPPs such as the ones on Big Data, robotics, 5G, High-Performance Computing, cyber security an important asset in Europe to advance collaboration and ensure quick market uptake. Large projects such as those mentioned in section 5.2.1 can help towards adoption of new technology in the Health and Care domain, in particular by scaling up what is working already and by testing what is new.

5.6 Contributions from Member States

Member States can contribute by engaging more actively in the assessments of opportunities for federation, based on successful (national) bottom-up platforms. The 74 Reference Sites from the EIP-AHA already represent leading regions within Member States that are willing to spearhead upscaling of innovative solutions for digital transformation of health and care.

Member States are also invited to engage further through mobilisation of relevant national initiatives which can make a strong contribution to taking this vision forward. This could include testbeds and innovation centres, providing access to health and care data resources and by being an active partner in the implementation of the joint vision.

In this domain Member States also have an important role to play by addressing and harmonizing regulatory, legal and ethical aspects of digitization in the domain of Health and Care.

6. Overview of the Strategy in "Industrial Data Platforms"

6.1 Introduction

Industrial Data Platforms (IDPs) are virtual environments facilitating the exchange and connection of data between different companies and organisations within a secure business ecosystem, through a shared reference architecture and common governance rules. Such platforms are of three main types:

- Community-led sector-specific (vertical);
- Community-led cross-sector (horizontal);
- Proprietary with open interfaces.

IDPs may take the form of open, multi-company-led environments that meet the requirements of a wide ecosystem of users from different industrial sectors. They can, however, also take the form of single company-led initiatives where an individual company or organisation establishes its own platform and opens it to others for commercial purposes. Common governance rules, in particular, could technically implement an open, generally recognized process and a standardised data ecosystem for the transfer of property and possession on data assets.

IDPs will be crucial for the digitisation of industrial production[19] because they could provide the technical infrastructure that allows data to be shared with the players that make best use of them. This should happen while respecting the rights and interests of the party that has invested into the collection of the data.

In the context of the DEI, the aim is to support the development of competitive data platforms and the availability of a world class data infrastructure in Europe. The data platforms should be open to new data actors interested in sharing data. Piloting actions would aim to support the development of virtual environments facilitating IDPs. Key aspects include legal and technical conditions to help businesses to make safe and secure exchange, transfer, access and reuse of data. Stakeholders consider public intervention critical to support first production and deployment of IDP technology.

6.2 Current landscape of activities

6.2.1 European initiatives

Several interesting examples of Industrial Data Platforms were noted during the meetings of WG2. We mention two concrete functional models, where innovation on top of data can take place.
The Industrial Data Space (IDS) initiative[20] was launched in Germany in 2014 by representatives from business, politics and research. The IDS recognizes data as:

- The result of a process;
- An enabler of processes;
- An enabler of products and services;
- As a product.

The IDS aims to develop and pilot test a reference architecture model for a secure virtual data space using standards and common governance models. It thereby provides a basis for creating and using smart services and innovative business processes while at the same time ensuring digital sovereignty of the digital data owners. More specifically the IDS is based on the following principles:

[19] See the report: Industrial Data Platforms – Key Enablers of Industry Digitization European Data Market SMART 2013/0063 D 3.10.
[20] Outlined in the White Paper: Industrial *Data Space; digital sovereignty over data* https://www.fraunhofer.de/content/dam/zv/en/fields-of-research/industrial-data-space/whitepaper-industrial-data-space-eng.pdf

- An open approach that is neutral and user driven;
- A decentralised approach, based on a distributed architecture;
- Trust between the users, based on the use of certified software;
- Data sovereignty, because the data owner always determines the terms and conditions of the data provided;
- Secure data exchange, across the entire data supply chain;
- Data governance, based on rules that are derived from the requirements of the users;
- A network of platforms and services;
- Economies of scale and networking effects.

Access to data owned by another party is based on bilateral agreements, which are based on templates developed by the IDS. Crucially, the party that owns the data does not surrender control over it when it engages with the IDS. The initiative has since evolved into two strands, a research project and non-profit user association with membership in Germany and several other European countries.

An example from the private sector is MindSphere, an open industrial cloud platform developed by Siemens and SAP. OEMs and application developers can access the platform via open interfaces and use it for their own services and analyses – for instance, for the online monitoring of globally distributed machine tools, industrial robots, or industrial equipment such as compressors and pumps. Using MindSphere, customers are also able to create digital models of their plants with real data from the production process. This allows them to synchronize the model and the plant, to carry out simulations and optimize business processes. In the future, users will also be able to develop their own web services with MindSphere as a basis for digital services such as predictive maintenance, energy data management, or resource optimization.

Concerning possibilities for funding, Innovation Spaces (i-Spaces) is one of the four main implementation mechanisms of the Big Data Value PPP under H2020. i-Spaces are cross-organisational and cross-sector environments that allow challenges to be addressed in an interdisciplinary way. i-Spaces will serve as a hub for other research and innovation activities. They bring innovation providers, such as data innovators, together with users and allow the two to experiment in a secure environment. i-Spaces will be incubators for new business models and skills bringing together data owners and data users.

The BDV PPP is also working with Lighthouse projects, large-scale projects serving as incubators for whole data-driven ecosystems. These will help raise awareness about the opportunities offered by Big Data and the value of data-driven applications for different sectors.

The FoF PPP is also active in this area, e.g. through its work on data management for increased production performance and linking products and processes to innovative services.

6.2.2 National and regional initiatives

Many Member States also have Big Data initiatives, including Germany (Smart Data Forum), Denmark, Netherlands, Spain and UK. A European Network of National Big Data Centres of Excellence has also been launched to facilitate cooperation in research and education of data workers. In many countries (consortia of) universities recently launched new research and education programmes devoted to Big Data, e.g. the newly formed Jheronimus Academy of Data Science in The Netherlands (a collaboration of Tilburg University and Eindhoven University of Technology) which also has industrial sponsors, such as Philips.

6.3 Visions for the future

6.3.1 Needs and expectations

Sharing data can create significant technical challenges, e.g. related to standardisation and interoperability, but may also trigger issues in other areas, in particular the legal domain. Disputes can easily arise about who is the owner of the data and about the (limitations to) rights of access and use that may exist. For instance, questions of data ownership often arise in sensor-intensive applications such as in the agriculture and healthcare domain. With a factory machine, for example, data may be collected and shared for various purposes (e.g. for preventive maintenance) between several parties: the owner of the machine, the manufacturer, the lessor, etc.Various types of law are relevant here, e.g. IP law including database law and design law, privacy law and competition law. Clarifying the relevant legal regimes can be complicated and time consuming, especially in an international context. The European Commission has launched a public discussion on these issues within its initiative 'Building a European data economy', released in January, 2017[21]. The communication addresses:

- The free flow of data
- Data access and data transfer
- Liability
- Portability, interoperability and standards
- Experimentation and testing

It should be noted that IDPs can provide technical solutions that tackle some of the legal issues, by way of defining rights of participating actors over the data exchanged over the platform.

Experience with automated milk machines in the Netherlands provides a useful example. In order to maintain the machines the manufacturer collected detailed data, including the milk yields of each cow. They realised that this data constituted a valuable resource: one potential market was with local veterinarians. The farmers, as owners of the cows, believed that they were the real data owners and had a key interest in how the data was used. The two parties agreed to create a platform to share the data which has proved beneficial for both. The farmers have better information on yields. The manufacturer has created a foundation to collect and store the data, and has been able to capitalise on export opportunities to large-scale farms in China. The message: platforms prompt transparent discussions on trust.

6.3.2 Bridging the gap and addressing the issues

A fair legal regime has to accommodate the interests of those who originate the data and those who wish to use it. It may be necessary to develop a series of legal templates, to ensure that the interests of the various parties are protected and no party will claim exclusive rights (which in turn could lead to rents). Such model contracts would be made readily available by an IDP and be applied to data exchange scenarios performed on the given platform. IDS has also created templates as a foundation for bilateral agreements.

It was noted that under the IDS framework data owners retain legal ownership. There are framework contracts between companies that exchange data but at the moment these are not enforced by technology.

From the technology perspective, it was noted that Europe should be more aggressive in demonstrating use cases for Blockchain. This new technology, which is used in several Internet currencies (notably BitCoin), will be very disruptive, arguably leading to more job changes than robotics. One advantage is that, by avoiding the need for a central point of coordination, Blockchain

[21] https://ec.europa.eu/digital-single-market/en/news/communication-building-european-data-economy

offers a more transparent market in all forms of contracts. For example, in telecoms, there would no longer be a need for a centralised database in order to handle number portability between service providers. In the US more than US$1bn has already been invested in Blockchain-related startups, whereas Europe has invested very little.

6.3.3 Priorities

Lack of skills is the main barrier to the proliferation of Big Data approaches. Without dedicated action the shortage of good data scientists will only increase. Joint action is needed to educate many more people with the appropriate skills. A Coordination Support Action 'BDVe' will from 2017 support the establishment of national centres of excellence, in order to exchange knowledge on the universities' data science programmes and to align curricula & training programmes to industry needs.

The possibility of certification of parties who are involved in IDPs should be investigated further. When parties are certified to have a certain level of maturity with regard to the exchange of data, organizing data exchange will be easier. In that case it will also be less complicated to organize multilateral data exchange.

The IDP landscape is complex. Many use cases and experiments are needed to fully understand it. The EU and Member States should collaborate to create an environment that encourages those experiments and contains instruments for federation.

Rules would need to be clarified at EU level regarding minimum standards on security, confidentiality, access to data by the worker, legitimate processing of data and international transfer of worker-related data (specifically: outside the EU).

6.4 Implementing the vision

A key requirement is to ensure that the benefits of the data economy reach SMEs in all sectors, including traditional sectors such as agriculture. Initiatives such as the i-Spaces and Lighthouses will be important here. The Lighthouses aim towards replicable solutions across various communities and settings, through deployment based on verticals and utilisation of national initiatives.

There is no value in data without context. The notion of ‘digital twin’ (i.e. ultra-realistic computer modelling) is increasingly used in various sectors and requires very rich data, standardised models and semantic models.

Reaching a sufficient scale will be crucial to ensure appeal of IDPs, as for any multi-sided market.

There are two potential approaches in exploiting Big Data which may be summarised as: a ‘fishing’ approach, where users look for correlations in/from unstructured data in the hope of extracting value; and a ‘targeted data collection on everything’ approach, where huge amounts of data are collected and systematically analysed and the results presented through dashboards. The former is seldom a sensible approach for a business as they need to know what they wish to achieve, and therefore which datasets to analyse and to integrate. Preventive maintenance and many other examples rely on the second, very structured and controlled approach. As storage becomes cheaper, it is more practical to store all possible data not just the most relevant bits. Thus, we need to think in terms of a hybrid ‘discovery’ approach: store everything and then look for the correlations later. One potential use will be in machine learning, where the massive stores of data will be a very valuable resource.

6.5 Contributions from PPPs

The PPPs will be key stakeholders in this area. BDV PPP, HPC PPP, FoF and SPIRE all have flagship projects that could form the basis of cross-sectoral IDP initiatives.

Most platforms will be vertical to some extent, addressing the needs of specific sectors. The options to organize this are essentially two-fold: the foundation/ association approach (as with IDS); and the provider ecosystem approach (as with Siemens MindSphere and automotive platforms).

6.6 Contributions from Member States

Cooperation with Member States is essential to reinforce the role of PPPs as coordinators of EU-wide R&I effort, national initiatives and industrial strategies by focusing on key technologies and their integration through large scale federating projects. It is also important to address a significant part of the PPPs and national investments in this domain on cross-sectoral and integrated digital platforms and ecosystems including reference implementation and experimentation environments in real setting.

However, few examples of IDPs from the Member States are visible at present. This is clearly an area where more communication and a more thorough mapping is needed to identify opportunities for leverage and federation. That type of communication will also spread the IDP-concept within those Member States, where it is still not widely known. It could be useful to examine the possible role of Digital Innovation Hubs in the development and take up of IDPs.

7. Overview of the Strategy in "Internet of Things"

7.1. Introduction

Within the IoT sector there is currently a zoo of platforms and the domain is dominated by the US. Although there are 3BEuros of investment in national IoT strategies, national initiatives addressing platform building will not be able to compete at an international level as there is insufficient "home" user base. Many start-ups are created, but they are prone to takeover when they mature. In order to compete there is a pressing need for Europe to co-ordinate activities to create critical mass and avoid fragmentation and silos. However, in addition to addressing interoperability between platforms there is also a need for clear approaches that respect privacy and security.

Thus, in this area maybe even more than in the others the EU needs to supply long term support with a clear mechanism and objectives to support European Platform building. It also has a key role to play in promoting fair rules, standardisation and guidance on data governance and security. The aim should be to promote openness to avoid lock-in, prevent the dominant position of one player while monitoring global competition, and provide supporting standards, regulation and policy.

In order to tackle fragmentation the implementation of platforms across Member States should be coherent, addressing key sectors and societal challenges. To encourage uptake there is a need for pilots at both lab-scale and in real environments, particularly at the regional scale. Key aims should be to support test beds and trials that demonstrate standards, data sharing, federation and interoperability. It is important that pilots are replicated in other regions to promote Best Practice and accommodate for the "Penguin Effect"[22]. Clearly, mitigation of this effect requires active coordination, to mobilise uptake and effectuate digital transformation in a direction that is visible to all.

A number of key initiatives are funding projects in the area of IoT such as FoF, ECSEL, Big Data, 5G and AIOTI. Coordinating these activities on cross-sectoral and integrated digital platforms would be very powerful. Bodies representing the sector, e.g. AOITI and ETSI, could provide horizontal coordination for this with the aim of bringing together PPPs and national investments. The aim would be to create cross-sectoral and integrated digital platforms and ecosystems including reference implementations and experimentation environments in real settings. IoT incubator communities of start-ups and developers can then be used to promote the technologies to the SME community.

7.2 Current Landscape of activities

7.2.1 European initiatives

At the European level the IoT-EPI cluster brings together 7 RIAs and 2 CSA projects to work on emerging IoT platforms. Task forces have been created to address horizontal issues such as Innovation, Accelerators (how to accelerate scale-up), International Collaboration, Interoperability and Business Models. Already two documents related to IoT business models have been created highlighting a change towards value networks. Additionally, other large European initiatives, e.g. FoF and ECSEL (ARTEMIS-IA, EPoSS, Aeneas) are supporting IoT projects. Overarching the IoT activities across Europe, the Commission had created AIOTI (Alliance in the Internet of Things Innovation) in FP7 with further support in Horizon 2020. This is now an independent non-profit organisation with 500 members acting as a technology platform. Currently AOITI is becoming a legal entity to allow it to establish liaisons with other groups.

[22] The Penguin effect can occur in 'adoption games', when users are reluctant to move first (in adoption of e.g. a new technology, standard or platform) as long as there is a significant risk that the choice may be wrong and the technology selected will eventually be orphaned. To prevent this, participants in the game will tend to "wait and see". The term refers to the challenge penguins face, when they stand together before they dive into a sea full of fish, where however predators may also wait for them. The first penguin to dive in follows a high risk/low gain strategy.

Siemens is strongly pushing the vision of a web of systems approach for interconnection between many devices. To support this, standards for semantic interoperability are needed to connect different proprietary platforms and federate cloud services. This could include elements from the consumer, business and industrial domains to create a web for things or systems. Siemens avoids the term "Internet" as this is strongly focused on connectivity. It also avoids the term "Things" as it does not adequately describe systems. The company has a much stronger focus on the World Wide Web and services.

7.2.2 Regional and national initiatives

Many countries now have national initiatives for IoT. For instance, within the UK the Digital Catapult coordinates IoT activities and it was highlighted that there is a significant programme of IoT research activities (£120M projects - 10% coming from the EU) funded by the Research Councils and also Industry led programmes. £40M had been dedicated to large scale pilots in smart cities and two health care pilots. A research hub on IoT had also been created on security and trust and a further £14M had been allocated to two hardware accelerators. Overall 170 different IoT companies from a variety of different sectors are engaged (pre-dominantly in healthcare and transport). Venture Capital was also strong for IoT with 45 companies receiving £40M. It was noted however, that although money was available to support start-ups, later stage funding for growing businesses was more challenging which often led to companies being bought out by international companies. A large proportion of UK IoT activities (75%) were in the London/Cambridge region. Many activities in the UK are not linked with Europe and there is interest in collaboration. Likewise there are national strategies in France such as "La French Tech" for digitisation with a number of supporting regional initiatives addressing key technologies and Industrie 4.0 in Germany which is supporting IoT-related research for manufacturing.

7.2.3 International initiatives

A study around the world by the Unify-IoT project has identified that around 360 known platforms exist, with the vast majority of these being developed from 2013 onwards. The initial explosion of new platforms and SMEs in the area is, however, slowing down. There will thus be a natural selection within the market over the next few years. The risk of US dominance was highlighted and large companies such as Google have the resources to dominate the future market. Google for instance has acquired a number of robotics companies recently. A notable difference identified between Europe and the US is that less barriers to deployment exist in the US. Another notable difference is that within Europe there is a generous culture towards internationally collaboration. In the US there is less interest in collaboration and the IoT area is driven by private investment, targeting a sizeable home market of 350 Million people before markets beyond the US are considered.

The threat to Europe, however, is a world-wide one and it was highlighted that any company can be bought as evidenced by recent acquisitions of ARM, Kuka, etc. There is thus a risk of losing EU investment in innovation in the area. In particular it was noted that Europe has lost leadership in the B2C area. However, the position with respect to the B2B market is better and there is scope for standards development and obtaining market share. It was noted that Europe is strong in mechatronics, systems integration and the automotive sector. Within Europe, work on platforms is concentrated on connectivity which reflects Europe's strong history in communications, connectivity and sensors. The US is stronger in the area of Big Data and data platforms where there is more added value from exploiting data aggregation and analysis.

A distinction was made between IoT for consumers and Industrial IoT with the first covering smart phones, fitness tracking tools etc. and the second being exploited in areas such as smart factories, smart health care, etc. Advances are being made in the consumer world and a question is how this can

be moved to the industrial space. In general there is a convergence of consumer and industrial Internet with IoT becoming a "virtualisation infrastructure". Analysis of industry by IDC shows that 58% of organisations see IoT as strategic to business, while 24% of organisations see IoT as transformational to their business.

It was noted that the rise of the Circular Economy may offer opportunities for linking the consumer market to industrial processes, so as to capture use information on the product life cycle for maintenance, repair, upgrade/retrofit/refurbishing, dismantling and recycling. Within the industrial IoT domain GE is a strong player and is already in discussion with Bosch and Microsoft, all having joined the Industrial Internet Consortium (IIC). It was highlighted that if the large companies drive the market, the dominant solutions of the future may not match EU goals or be in the best interest of the EU. Open standards or APIs, accessible and usable under Fair, Reasonable and Non-Discriminatory (FRAND) economic and legal conditions are essential to give SMEs access to new technology and leverage the dynamics of new ways of making business as proposed by start-ups.

7.3 Visions for the Future

7.3.1 Needs and Expectations

Already there are a number of pilots being pursued and there is an opportunity, for instance, to put together the autonomous driving pilots being performed by IoT, ECSEL and 5G PPP (addressing communications for autonomous driving). There was a call for IoT platforms to be sector driven and to identify urgent problems. Interoperability of platforms and data is important and in the future the expectation is for more automated interaction between machines with reduced involvement of humans. Here there is a need to support standards as a key element of platforms. Looking to the future next generation platforms should take into account areas not currently addressed, e.g. the Circular Economy. The key need is to provide interoperable solutions that provide an experience that customers or business require, as well as guidance for secure and safe implementation (e.g. based on reference architecture models). Already a convergence is becoming apparent with the consumer space focussing on IT, and business focussing on operational aspects having more stringent requirements on timeliness, reliability and security. However, security and privacy need to be addressed at different levels and in the future platforms in the IoT space will be used to co-create value. Privacy needs to be protected within each sector and the EU has a role to play in providing data governance that supports European values. See Figure 8 for a schematic representation of consumers' feelings about using/selling of data about their behaviour, based on a 2015 survey by the Altimeter Group.

There is a need to identify the type of market value Europe wants to create. In the US targets are set reaching out for huge volume, and these are then pursued to create new technologies or increase market share. The current landscape of IoT platforms highlights that the European offer is very fragmented. Across the 360 platforms identified world-wide there was a mix of cloud companies, some open source platforms, some industrial sector driven platforms, e.g. by Bosch, Siemens or GE, and some standards based solutions. Looking to the future, international standardisation organisations, such as OneM2M, will be important and there is a need to create commercial platforms based on agreed international standards. There is an opportunity for gaining business in the edge computing domain as more processing will move close to the point of interest in the future and European companies have a strength in this area. Across Europe there is a need for a common, uniform market place to allow industry to up-scale their platforms and services to fully exploit the potential of a European digital single market. To be successful there is a need for market pull so that platform developments respond to requirements. Experimental pilots would bring together the supply and demand side. There is also a need for a strong IoT incubator space, building on the dynamics of a vibrant IoT developer and start-up community (as it is the case in U.K.) and access to finance within Europe to create platforms.

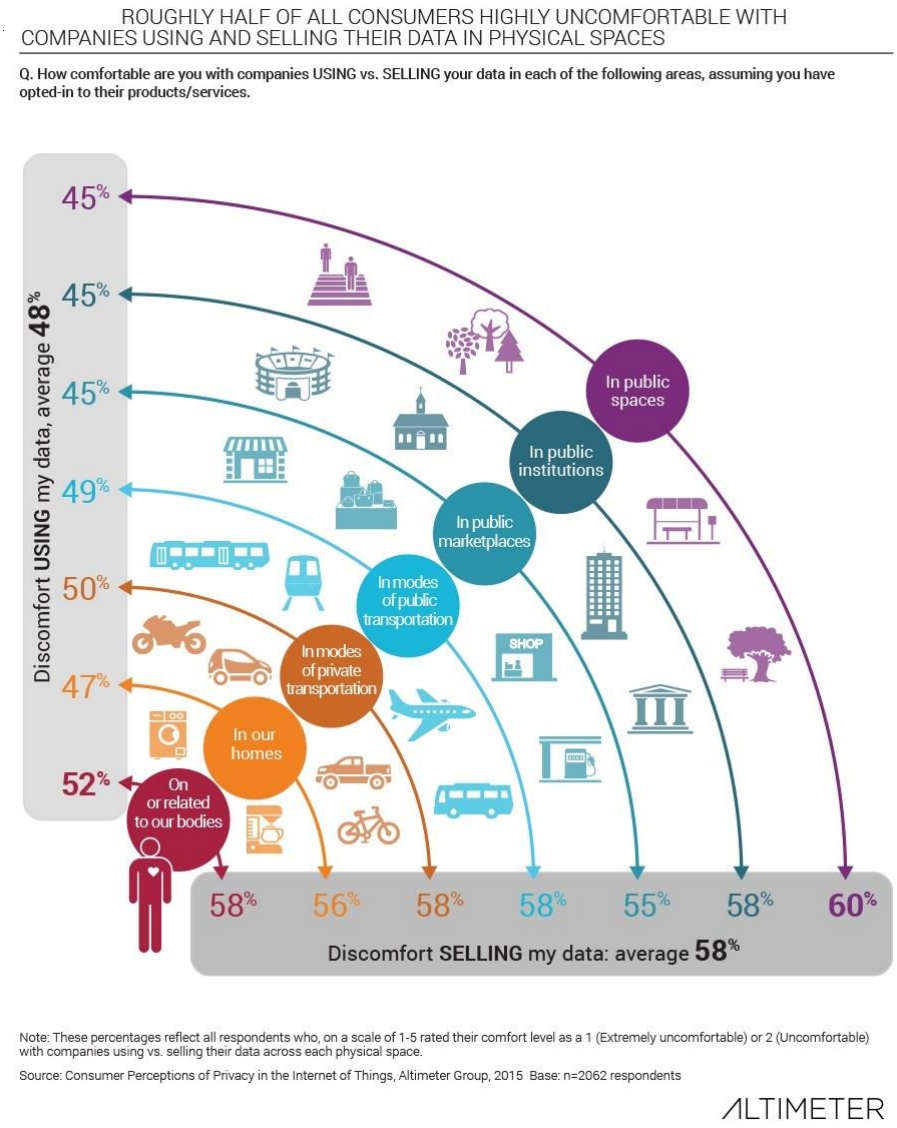


Figure 8: Data use and consumer perception of IoT

7.3.2 Bridging the gaps and addressing the issues

Platform development and large-scale initiatives at a European level should address consumer IoT applications as well as industrial IoT, one inspiring the other. There is a need for PPPs to coordinate with one another and link their large demonstrations that address IoT and related technologies like Cyber Physical Systems (CPS). Interoperability issues, standardisation and the architecture used by the diversity of platforms all need to be addressed and mechanisms are needed across Europe to up-scale platform building and stimulate innovation.

7.3.3 Priorities

WG2 identified the following priorities for IoT:

Platform Building - Connecting Regional and National Initiatives across Europe
Already there is a plethora of platforms and convergence is clearly needed. This should be driven by market pull and the opportunity for Europe is in areas such as mechatronics, systems engineering and automotive. There are a number of national activities on platforms and it would be beneficial to share

information between these. However, there are some challenges. Useful information on the impact of platforms is not yet available and platform development is driven by different sectors. For instance, in France platform development is being driven by the micro-electronics industry and in the UK it is driven by applications. This leads to differences in national IoT strategies.

Initiatives that foster more explicit actions between Member States are needed that spread best practice and also increase the awareness of IoT. A horizontal approach is needed to support convergence of IoT platforms and the benefits can be maximised through coordination at a European level via connection of regional and national innovation hubs. Here one approach may be to fund a CSA to share experience and catalyse national initiatives. There is also a strong need to coordinate across PPPs and link their IoT demonstrations. This could be further supported at a European level by an ECSEL-type activity, using national IoT funding.

Creation of Open Platforms

There is a need for open platforms to avoid vendor lock-in. With the proliferation of platform offerings there is considerable fragmentation and at present there is no clear convergence towards one platform. Key aspects include the development of a reference architecture that allows for cooperation across value chains and openness to SMEs. It is very important for Europe to transform its IoT research results into innovations that succeed on the market. As large companies have frequently difficulties in integrating research results into their business model, SMEs could have a crucial role in leveraging the potential of IoT innovation, because they are faster in developing applications and exploring less conventional solutions. Future platforms should bridge the current interoperability gap between the vertically-oriented IoT platforms and mobilise third party contributions by creating marketplaces for IoT services and applications. A harmonised European market for IoT interoperability standards and open APIs are a prerequisite for a free marketplace which reduces dependencies and barriers for new business and SMEs.

Privacy and end-to-end security solutions should be addressed based on local reasoning and trust, validating novel business models when data is aggregated and shared across the value chains. Emphasis is put on open platforms cutting across sectors and acceleration of innovation by companies and communities of developers, building on existing open platforms that support digital transformation and cross domain adoption.

By bringing the ecosystem together, for instance by linking European projects focussed on autonomous driving such as 5G, ECSEL, and the IoT Large Scale Pilot it may be possible to create open platforms addressing several sectors. The main stakeholders in this should be ECSEL and the FoF, SPARC and 5G PPPs.

Promotion of Standards

As highlighted the current fragmentation of IoT platforms creates challenges. There is a need to address interoperability between commercial or non-commercial platforms, e.g. focusing on semantics and ontologies. This requires collaboration on common interfaces for interoperability and a starting point here could be addressing interoperability at different levels for the use cases supported by the EU funded Large Scale Pilots. This would support convergence of platforms through deployment and via creating critical mass. Large-scale pilots are instrumental to validate emerging standards and thus support standardisation activities. The focus should be on a European approach to standards that would eventually influence standards at an international level such as oneM2M or W3C in the case of defining semantic interoperability. The emphasis should be on developing a convergence on existing standards rather than in generating new platforms and new IoT standards. The policy and regulatory framework needs to support this.

Promoting Industrial Partnership

The overall objective should be to create an Industrial Partnership. This will facilitate successful exploitation. Many IoT platforms already exist and there are growing partnerships such as the IIC and

the AIOTI. However, there is a need to promote a dialogue across a critical mass of stakeholders, including large companies as well as SMEs, and to promote consensus on platform up-scaling. This can be supported by the AIOTI with the aim of bringing different communities together. Legal issues, technical bottlenecks and market barriers need to be discussed. The aim would be to drive the convergence of standards across different sectors and accelerate adoption of IoT platforms in relevant sectors (sector-specific) whilst promoting spill-over effects to other sectors.

Supporting Large Experimental Facilities

To promote acceptance and prove the reliability of platforms there is also a need for large experimental facilities for testing and demonstration of novel standards, architectures and platforms, driven by selected verticals. Here there is a key need to avoid silos and a need to avoid vendor lock-in. Open standards and open APIs are important elements to allow SMEs to access and exploit an IoT platform. To ensure this it is important that small SMEs and start-up players get involved in these activities to address new business opportunities and business models. Here the emphasis should be on supporting convergence to fewer but open platforms, accessible and usable under FRAND economic and legal conditions. As highlighted Europe is strong in connectivity, which creates value that is distributed along the whole supply chain but weaker in the area of Internet platforms and Big Data analysis where the value is more concentrated and thus more visible. To address this gap there is also a need for connection between IoT platform development and other areas such as artificial intelligence, data analytics and security, etc. to capture market share. Fragmentation needs to be avoided through a coherent implementation of large-experimental facilities across Member States, vertical sectors, and across societal challenges. Large-scale pilots should build on converging technology trends integrating Artificial Intelligence, cloud, data analytics, robotics and edge computing, and addressing more application areas (smart living environment, smart agriculture, smart grids, smart cities, intelligent transport systems, automated transport, environmental monitoring, etc).

7.4 Implementing the Vision

7.4.1 Objectives for next generation platforms

An immediate issue is to define a strategy to address and coordinate developments in the "soup of platforms" that are emerging. A key need is interoperability to allow platforms to be connected together. As more critical applications are connected via networks, e.g. autonomous driving, there will be a need for higher quality network connections. If high quality networks cannot be guaranteed there will be a need to keep processing local. Indeed there is a growing trend towards data processing close to the point of action, i.e. edge computing, to address real-time availability in platforms and also to limit liability and risk that would otherwise be incurred from performing processing in central clouds.

A vision and strategy is needed to achieve this. Here reference implementations could be used as test cases in order to develop a good strategy. There is a need to define a list of objectives to organise actions so that the degree of success of initiatives can be monitored. These objectives should consider both the future vision and also societal challenges, and not only the industry objectives. It was noted that there are a number of cross cutting topics that could be addressed that would have impact across domains such as autonomous vehicles, industrial robotics, robotics for ageing well and farming. The importance of supporting infrastructure for industry was noted. For instance, the best effort approach provided by the Internet presently is not sufficient for some real-time services, particularly if a provider is asked to provide Service Level Agreements. This is becoming more of a problem as applications move towards using cloud platforms. This needs to be addressed at both the research and policy levels. At the research level, research is needed into new communications technologies such as 5G virtualisation and slicing to support different communication criticalities.

The future promises increased reliance on networks being interconnected to each other with the need for a connection to a reliable backhaul infrastructure. Notably there is a need to define what a "service" is, considering the growing move towards mobility as a service, health as a service, XaaS,

etc. The infrastructure needs to be put in place to support different application domains with differing real time requirements. End-to-end security and security by design needs to be provided considering devices, platforms and the connecting network.

7.4.2 Definition of Supporting Initiatives

There is a need for de-siloing of development. Already there are a number of developments underway such as Industrie 4.0, Farming 4.0, Energy 4.0, Health 4.0. This bears a high risk that security, standards, applications and infrastructures are developed/deployed in silos. The highest benefit for IoT is created if data is shared and exploited across vertical sectors. This creates a need for coordination to develop solutions that apply across sector value chains. It was highlighted that the EU should play a role in this and maintain a long-term position. There is a need to ensure that monopolies are avoided and that the rules applied for platform development are fair and move in the right direction for Europe. Openness is needed, to support SMEs and also to encourage dynamic ecosystems. Privacy and security guidelines need to be developed that are win-win. Care needs to be taken to avoid creating "ivory towers" or platforms that will not be used in practice. Hence there is a need to identify supporting business models and define platform economics. A key need is for open platforms and these must be attractive across different verticals. To prevent vendor lock-in, interoperability and connection of different platforms should be provided, i.e. via platform gateways, to de-silo platform development.

It is up to ecosystems in Europe to bring platforms together, but the EU can provide support for experimentation of new business models considering multi-sided market players. It was noted that applications across domains would be a good way of demonstrating federated platforms. Potential key areas have been suggested that could be fruitful to support platform building. These include energy management in grids, homes, cities, autonomous systems and data management for farming, IoT for water management, fish production, autonomous systems and smart home for health and well-being as well as smart mobility in cities (which combines autonomous systems and energy efficiency). Another application across domains, currently not addressed, could be the Circular Economy which could demonstrate federated platforms. The need for federated platforms is most evident for the domain of Smart Cities as it encompasses a number of topics such as mobility, energy, environment, waste and water management and autonomy to aggregate data from various legacy platforms. This would also address cross-cutting issues such as connectivity, sharing of data between platforms and legal issues as well as demonstrating mixed criticality services. Another potential area would be in manufacturing. Here a central search engine for manufacturing data could be developed with different platforms being used to organise process and supply chain logistics.

Connectivity is another key area that needs to be addressed. Already the lack of connectivity in rural areas for autonomous cars is causing concerns. For instance, if autonomous cars use 4G LTE for connectivity there are many areas where they are not covered and thus the need for a fall-back option exists. In reality it is necessary to test a patchwork of wireless and satellite connectivity in rural areas. However, it must be stressed that IoT is not only about connectivity. It cuts across many applications, e.g. autonomous cars, service robots, drones, cobots and health care as well as energy and public transportation. Google is for instance providing a platform for autonomous vehicles where the primary interest is in data analytics and Apple has also announced a "self-driving platform" for autonomous cars.

When choosing the right way of platform support a clear distinction should be made between marketplaces building on a dominant position and platforms driven by industrial cooperation and alliances. Whereas Google and Apple promote a top down approach to platforms adoption, GE is promoting an alliance forming approach in the Alliance for the Industrial Internet of Things (IIoT) to promote wider up-take of its preferred platform. This has led to Predix and ThingWorx being promoted via the alliance across a number of sectors. There are also a number of competing consortia

to IIoT such as IIC, Open Interconnect Consortium and Allseen Alliance. Here the EU should support a middle way that promotes the interests of European commercial and non-commercial platform developers, reduces dependencies for SMEs and start-ups, and allows seizing the benefits of new business models and innovative services across societal challenges, by making sure that the platforms can be accessed and used under FRAND economic and legal conditions.

The key need is to support the European SME ecosystem to empower them to meet international competition. Platforms need to be attractive to SMEs, providing interoperability to avoid fragmentation while supporting security by design. Trust in platforms needs to be developed and supporting regulation should be linked to the evolution of the platforms, providing standardisation and enabling data valorisation.

Demonstration of platforms should be done at a suitably large scale and in real environments to provide confidence to industry. Ideally the pilot demonstration should address societal issues that are of interest across Member States and involve PPP pilots that operate across sector stakeholders, such as FoF, ECSEL, 5G and SPARC. For uptake there is a need for replication of demonstrations of platforms across Member States in applications to address the "Penguin Effect", and make sure it does not take too long before good examples are followed.

Regulation should be linked to the evolution of the platforms. The industrial internet poses new challenges for security, liability, and data ownership which requires policy makers to adapt the regulatory framework. Evolving new business models, increasingly integrated supply chains and a hyper-connected society are to be considered before legislative decisions are taken. Pilots and testing with real use cases would support the shaping of the future digital policy. Evaluation of pilots should be closely coordinated with Member State initiatives, allowing the collection of broad feedback on possible policy options before regulation is put in place.

7.4.3 An action plan

As highlighted the EU needs to supply long term support with a clear mechanism and objectives to support European Platform building. It also has a key role to play in promoting fair rules, standardisation and guidance on data governance and security. The aim should be to promote openness to avoid lock-in, to support fairness in the distribution of the value added along the supply chain, to prevent the dominant position of one player while monitoring global competition, and provide supporting standards, regulation and policy.

Already there is 3BEuros of investment in national IoT strategies and in order to avoid fragmentation and silos there is a need to try and coordinate work at a European level. It is natural that SMEs will engage with regional and national initiatives, however, national initiatives addressing platform building will not be able to compete at an international level as there is insufficient user base. Thus there is a need to encourage collaboration and to build spearheading platforms that build a link between initiatives that address different use cases. At present there is one large scale pilot for one sector but it is important to replicate pilots in other regions and promote Best Practice. Here it is necessary to support multiple demonstrations and mobilise transformation.

There is a need to support SMEs. Standards are needed for security and to provide interoperability between the many platforms that currently exist. In order to tackle fragmentation there is a need for coherent implementation of platforms across Member States addressing key sectors and societal challenges. In order to encourage uptake there is a need for clustering to create scale. This can be done using pilots at both lab-scale and in real environments particularly at the regional scale. Key aims of this should be to promote standards and data sharing with test beds and trials that demonstrate federation and interoperability.

7.5 Contributions from PPPs

Several large scale pilots already exist that plan to introduce IoT in specific verticals, such as agriculture or health and care. Examples are IoF2020 (in Agriculture), ACTIVAGE (Health and Care) and AUTOPILOT (autonomous driving cars). Projects such as these can provide a foundation for further adoption of IoT in verticals.

As there are many common themes being researched by the PPPs, coordinating activities between the ECSEL, Big Data, 5G, etc., PPPs on cross-sectoral and integrated digital platforms would be very powerful. Here alliances like AOITI and ETSI may also have a role to play, providing horizontal coordination. The aim should be to focus a significant part of the PPPs and national investments on cross-sectoral and integrated digital platforms and ecosystems including reference implementations and experimentation environments in real settings.

7.6 Contributions from the Member States

Input was received from a number of Member States including France, the Netherlands, Germany, United Kingdom, Sweden and Austria. It was noted that France is keen to have a common standard platform for IoT that is agnostic of hardware. There are big initiatives in the UK on IoT, Smart Cities and 5G. Additionally, the UK is also looking to develop technologies to address markets in other parts of the world, such as China and India. Within Europe with respect to platforms a national market is not sufficient for survival and scale can only be provided by addressing platforms at a European level. Here the US has an advantage of a large internal market.

One approach to trying to bring developers together to create scale would be to develop smart specialisation platforms so that regions do not develop their own platforms in isolation. For this it is necessary to convince regions to get together at the European level and develop interoperability between existing platforms. This bottom up approach requires horizontal coordination of development of federated platforms. Here AIOTI and ETSI have a role to play to create EU alliances and promote standards.

8. Conclusions

The very significant opportunities associated with Leadership in Industrial Platforms are recognized everywhere, not only in Europe. Organizations around the world invest very substantial amounts to obtain an attractive position in a context of digitised industrial ecosystems. By 2020, the world-wide investment level associated with digitisation is expected to be close to 10% of industry's total added value. In Europe, as elsewhere, many initiatives exist already, but they are not very structured. The three "vertical" domains (Smart Factories, Smart Agriculture and Digital Health & Care) and the two "horizontal" areas (and) that were assessed in more detail by WG2, currently all show a high level of fragmentation. For Europe joint action is the only option if the aim is to score effect at a global level. It is clear that European stakeholders will only succeed in making a world-wide impact through coordinated action.

The fragmentation that currently exists is expected to diminish more or less automatically over time, as a result of market forces. A few dominant players will remain in the end. However, if this development would be exclusively left to the market, many consider it unlikely that the result would be sufficiently aligned with European interests and values. Therefore, co-ordination, orchestration and regulation is considered necessary to ensure that the resulting platforms are truly leveraging the interests of European industry and will improve the quality of life of European citizens.

In this respect another thing is clear as well. If any industry in Europe, large or small, wherever situated and in any sector will be facilitated to fully benefit from digital innovations to upgrade its products, improve its processes and adapt its business models to the digital age, then any customer in any transaction and any worker in any position will be affected as well. Digitisation will thus fundamentally change not just industry, but what we do in society at large. Commissioner Oettinger argued during the closing speech at the First DEI Stakeholder Forum on February 1, 2017, that the investment in the infrastructure for digitisation is probably the most important one that will be made by this generation. Definitely, no other infrastructucture will have a more pervasive and more ubiquitous influence on how we live and work. Every fisherman and every farmer, every cardiologist and every car mechanic, every teacher and every truck driver anywhere in Europe will be affected; everyone of the more than 250 million members of Europe's working population. Moreover, everyone of the more than 500 million inhabitants of the EU will feel the influence of digitisation, as customer and citizen. Hence, the standards that will be defined by the stakeholders in the industrial platforms of the future will together influence the ultimate standard: the standard of living in Europe. Thus, the need to collaborate is not just a matter of quantity, of creating clout to be competitive, it is a matter of quality too: of being representative and comprehensive enough to make the right decisions about investments in initiatives that are sustainable.

Hence, the recommendation is to create an open and inclusive environment between the EU and the Member States that encourages learning and consensus building regarding digital technologies and digital industrial platforms, based on experimentation and validation of test beds. WG2 stresses that to this end more attention should be given to the testing of existing platforms under increasingly challenging "real world" circumstances, as opposed to stimulating the development of yet other new (and local) platforms that are only validated in a lab. In fact, a variety of needs from different communities of users should be addressed and included in the process of validation. Projects that are considered promising because they meet the requirements of a broad range of stakeholders, can subsequently be further developed into large-scale initiatives.

This validation approach should be complemented by instruments for federation that will allow efficient upscaling of initiatives that are successful and show potential. To this end sufficient attention for interoperability and connectivity in platforms is key. The PPPs can provide an important role in this process, but other means to do this exist as well, at the European level or elsewhere. It is therefore important that relevant agencies sit together to compare and tune investment agendas, including consumer organizations and unions.

In this process significant attention should be given to non-technical aspects. Most notably economic, social and last but not least legal aspects were discussed quite extensively in WG2. Digitisation will create opportunities for new jobs and those with the right skills can benefit significantly from it. For instance, the lack of availability of properly trained data scientists is currently the main hurdle to the proliferation of Big Data approaches in industry and an urgent need exists for people with the right skills. However, digitisation will also eliminate jobs. Hence, the number of European workers with the appropriate knowledge and skills to face the challenges of digitisation should increase rapidly. Finally, digitisation creates many legal challenges. Some of them require a fundamental (international and comparative) re-assessment of legal assumptions, e.g. about the "owner" as defined in various branches of IP law and about the limits of their sovereignty to control the access to and use of their creations in whatever (digital) form. Clearly, these non-technical considerations only further emphasize the need for a dialogue between EU and Member States.

So far, not all Member States have contributed to the process of stock taking and suggesting opportunities for joint programming of roadmaps, co-investment in initiatives or regulatory and/or legislative harmonization. The WG2 community therefore strongly encourages all parties to sit together and, even more actively than they have done so far, assess where opportunities for collaboration, joint programming and federation exist. The debate within WG2 is ongoing and an updated report will be released in a few months.

A. Relevant activities in platform development, piloting, and testbeds

Note: this annex is work-in-progress. It will be filled with inputs received from an ongoing questionnaire, and with relevant activities known to the Working Group. It is expected that the information here will complement the information given in Sections x.6 "Contributions from Member States". Regarding pilot lines, there is a link and possible overlap with the work done by WG1 on Digital Innovation Hubs.

A.1 Platform development

An example of a digital platform is the Smart, Safe & Secure Platform – S3P, by the French S3P Alliance[23]. This software development and execution platform for the Internet of Things aims at enabling the rapid development and exploitation of IoT-capable devices and applications, combining safety, security, agility and portability. It is developed by a 45 M€ project, which is financially supported by the French Government "Nouvelle France Industrielle" initiative with an 18.3 M€ government funding.

The two most well-known commercial platforms in manufacturing are Predix[24] by GE and MindSphere[25] by Siemens.

In agriculture there are numerous examples: 365FarmNet[26] is an open platform for linking together applications and services of different manufacturers and service providers; MyJohnDeere[27] is a Farm Management Information System with an open API to allow access to agricultural machinery data to other systems such as those provided by SMAG and Agro-Office. Similarly PLM Connect[28] is a Farm Management Information and Decision System by New Holland, also with an open API.

Another example in the automotive sector is AUTOSAR[29]. In that sector, leading OEMs and Tier 1 suppliers work together to create a development base for industry collaboration on basic electrical/electronic functions while providing a platform which continues to encourage competition on innovative functions. To this end a development partnership called Automotive Open System Architecture (AUTOSAR) has been formed. It aims to create and establish an open and standardized software architecture for automotive electronic control units excluding infotainment[30]. The AUTOSAR standard will serve as a platform upon which future vehicle applications will be implemented.

A.2 Large-scale piloting

Relevant ongoing initiatives at EU level include the set of Large-scale Pilots called for under the Internet of Things Focus Area in 2016 (IoT-01-2016). These pilots address the challenge to foster the deployment of IoT solutions in Europe through integration of advanced IoT technologies across the value chain, demonstration of multiple IoT applications at scale and in a usage context, and as close as possible to operational conditions. The pilots are targeted, goal driven initiatives that propose IoT approaches to specific real-life industrial/societal challenges. There are currently five pilots active:

1. Smart living environments for ageing well (EU contribution up to 20 MEuro)

[23] http://www.esterel-technologies.com/S3P-en.html
[24] https://www.ge.com/digital/predix
[25] http://www.siemens.com/global/en/home/company/topic-areas/digitalization/mindsphere.html
[26] https://www.365farmnet.com/en/
[27] https://myjohndeere.deere.com/
[28] https://www.plmconnect.com/
[29] http://www.autosar.org/
[30] https://en.wikipedia.org/wiki/AUTOSAR

2. Smart Farming and Food Security (30 MEuro)
3. Wearables for smart ecosystems (15 MEuro)
4. Reference zones in EU cities (15 MEuro)
5. Autonomous vehicles in a connected environment (20 MEuro)

A.3 Testbeds

Labs Network Industrie 4.0 is an example of a network of manufacturing testbeds in Germany[31]. Networking the numerous testbeds enables distributed production and application processes to be simulated across several test environments. Labs Network Industrie 4.0 was founded in Germany as a one-stop shop for the coordination of the different approaches. It supports companies in the initiation of Industrie 4.0 projects, pools results from the testbeds, and forwards them to relevant standardisation and international cooperation bodies.

An example of a testbed is ARENA2036 – Active Research Environment for the Next Generation of Automobiles. The ARENA2036 research campus is a bridge between research and development in the field of lightweight construction and innovative production technologies. All activities of the ARENA2036 research campus are systematically combined in a "research factory". In the "research factory", the results of the development and construction research as well as the simulation can be tested immediately.[32] Digital manufacturing platforms could be implemented and validated in the research factory.

A.4 Major European projects/programmes

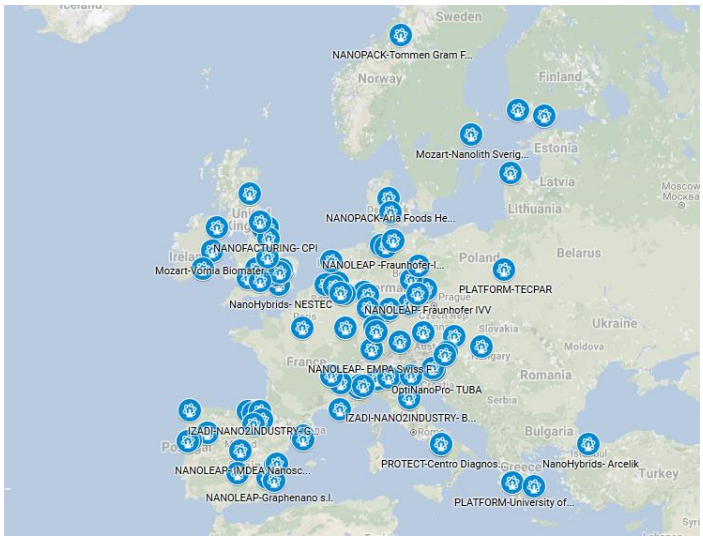
Programme	Projects	Objective	Stakeholder type	Public funding
Connected Smart Factories				
Factories of the Future	FoF-11 - automation	Reference implementations of platforms	Technology Providers Users	55 M€
ECSEL JU	ARROWHEAD - automation	Low-cost, service-oriented middleware for industry automation	80 partners users: Production, infrastructures, Electro mobility, Energy production	30 M€
ECSEL JU	Productive40* - supply chain	Create systems for planning, virtualising and controlling of - Supply Chain - Product Life Cycle	120 partner Techn. Providers Users from electronics, automotive, construction	tbd
Digital health & care				
IoT Large-scale Pilots	ACTIVAGE - cloud services - SC co-financing	Activate smart living environments for ageing well	Telco and IT services, electronics, system integrators	20 M€
CONNECT Societal Challenges	UNIVERSAAL - development tool for medical services	open platform for Ambient Assisted Living	IT services, system integrators	10 M€
Big Data Value PPP	AEGLE - personalized services	Multi-parametric platform for data analytics on biological data	System integrators, health industry, IT systems	5 M€
Future Internet PPP	FI-STAR - cloud services	Predecessor of ACTIVAGE		13 M€
Smart agriculture				
IoT Large-scale Pilots	IOF2020 - cloud services	Build a platform of cloud based App-like services for agriculture	Telco providers, electronics, user industry	30 M€

[31] http://www.plattform-i40.de/I40/Navigation/EN/InPractice/Testbeds/testbeds.html
[32] http://www.arena2036.de/de/arena2036/inhalte-und-ziele

Programme	Projects	Objective	Stakeholder type	Public funding
	- AGRI co-financing	industry		
Big Data Value PPP	DATABIO* - satellite data in agriculture	Optimise production with data analytics in agriculture, forestry and fishery/aquaculture	Communication and IT services, user from bio-economy (farming, fishing, forestry)	Tbd
Future Internet PPP	FIspace - cloud services	Predecessor of IOF2020		13 M€
Connected automated driving				
IoT Large-scale Pilots	AUTOPILOT - services for connected cars	Facilitate automated driving with connectivity	Automotive OEMs, IT and navigation services	20 M€
CONNECT Societal Challenges	SCOUT - 4G connectivity			
Big Data Value PPP	AUTOMAT - Vehicle Data Services	open ecosystem for vehicle Big Data	Automotive OEMs, IT and navigation services	5 M€
ECSEL JU	ENABLE-S3 - ADAS systems	Interoperability platfoms for engineering of automotive electronic control units	Automotive suppliers, software tool vendors Automotive OEMs, IT services	32 M€
ECSEL JU	CRYSTAL - AUTOSAR	Interoperability platfoms for engineering of automotive electronic control units	Automotive suppliers, software tool vendors Automotive OEMs, IT services	35 M€
RTD/MOVE Societal Challenges	CARTRE - WIFI connectivity	Coordination of Automated Road Transport Deployment for Europe	Automotive OEMs, tier 1 suppliers, IT services	3 M€

Pilot lines in nanotechnology and advanced materials developed under Horizon 2020 NMBP[33]
The PILOTS call activities of the nanotechnology and advanced materials areas in Horizon 2020 and FP7 have resulted in 30 projects with a combined funding of EURO 150 Million. Most of the PILOT projects have the objective to help transferring new technology into industry by providing open access for upscaling and pilot testing to SME users.

Additional investments by Member states, public or private organisations have contributed to establishing a variety of pilot upscaling facilities across Europe, mainly in the EU-15 countries.



[33] Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing

The map contains the location of 107 pilots, which use different raw materials (e.g. nano-cupper, nano-inks, nano carbides, nano borides, pellets, aerogels, graphene, nanostructures etc), processes (e.g. injection moulding, casting, nano-reinforced aerogel via freeze-drying, nanocomposites coating on a sol-gel basis, electrospray nanodeposition etc) and products (e.g. capacity touchscreens, B-pillar, swash plate, aerogels, novel functional products for skin thermal comfort, scaffolds for bone generation) etc. The products are addressing diverse sectors and markets, from automotive, aerospace, defence, energy storage, construction industry to cosmetics, health and packaging.

The aim, together with the European Pilot Production Network (EPPN), should be to establish a strategic approach to promote technology take-up and the use of these services in particular for SMEs and across regions ("access to technology" and support for upscaling).