Annex 1: Connected Smart Factories

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.[1] EFFRA, too, sees interoperable digital manufacturing platforms as central to its vision for factories of the future.[2]

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

- 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 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.
- Improve **energy and resource efficiency** and create **more sustainable value networks**, key steps towards making the Circular Economy a reality.
- 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.

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 EU actors join forces along common interests in the 'platform economy'.

Current European Landscape

Europe has a rich landscape of initiatives concerned with Connected Smart Factories. Initiatives are to be found in Member States, regions and at European level, including public-private partnerships (PPPs).

As a working framework, industry-driven platform initiatives may be categorised as:

1) **Community-led sector-specific**: These aim to develop reference architectures in specific industry verticals. Examples include: RAMI 4.0, a Reference Architectural Model developed under Germany's Industrie 4.0 programme; and FITMAN, a reference architecture for digital manufacturing based on the FIWARE technology of the FI-PPP.
2) **Community-led cross-sector**: These are more horizontal (i.e. non sector-specific) initiatives. Examples include: S3P (Smart, Safe & Secure Platform), a software development and execution platform for the IoT;[3] Industrial Data Space (IDS), a reference architecture for big data ecosystems;[4] AIOTI's work on reference architectures for the IoT;[5] and Crystal, a

[1] ERT Position Paper: Towards European Leadership in the Industrial Internet (August 2016)
[2] EFFRA Recommendations: Factories 4.0 and Beyond (Sept 2016)
[3] See www.esterel-technologies.com/S3P-en.html
[4] This development was discussed in greater detail in the IDP Session.
[5] See www.aioti.eu

reference technology platform for safety-critical systems developed under the ARTEMIS Joint Undertaking.[6]

3) **Commercial platforms with open interfaces**: Examples include: Siemens' MindSphere, SAP's Hana, Dassault's 3DEXPERIENCE, and Bosch's Cloud.

Two PPPs explicitly address manufacturing/production: Factories of the Future (FoF) PPP (discrete manufacturing) and Sustainable Process Industry through Resource and Energy Efficiency (SPIRE) PPP (industrial processing). Both 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:

- Open RAMI-based product-service lifecycle management environment;
- Open factory platform facilitating the encapsulation of production resources and assets; and
- Open design platform for additive manufacturing.

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

Developments are also underway at national level. The Netherlands, for example, has the Smart Industry initiative, including some actions clustered around the EU's Vanguard initiative. Spain has launched an Industry 4.0 initiative and is experimenting with various approaches. Italy's National Industrial Plan, announced in September 2016, foresees around €13bn investment by government and will be matched by €10bn from industry. It includes investment in competence centres and digital innovation hubs, some of which will be linked internationally.

Vision for the Future

As the above snapshot shows, fragmentation is a key problem. There are many initiatives, all with differing motivations, objectives and funding streams. We need to collect good practices and identify successful established platforms wherever they are to be found – including from outside of Europe – and should consider building on them rather than seeking to re-invent platforms and opening up new initiatives. This will be the quickest way to reach critical mass.

Traditional distinctions between business-to-business (B2B) and business-to-consumer (B2C) 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 and has suffered significantly at the hands of new entrants who have become monopolistic gatekeepers. Europe cannot afford other sectors – automotive, smart homes, smart cities – to go the same way. To safeguard their position these sectors have to become more focused on the consumer.

Machine-to-machine (M2M) platforms are also important in the context of CSF and are already being applied around the world. Europe has to compete here too.

[6] See www.crystal-artemis.eu

It is clear that the Circular Economy will require enormous traceability of industrial products in order to define where individual products are sourced, produced, disposed, 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**. Ultimately, there will be complete integration across value chains and there could be key first mover advantages for Europe. Arguably, this is one example of where platform interoperability or federating platforms are needed. Focusing on individual elements, at the expense of the bigger picture, risks losing the advantage.

How can large-scale federating initiatives help here? With so many competing initiatives, federation could help convince industry of the value of digital platforms and develop the ecosystem. Such initiatives must have clear added value for the constituency concerned and be driven bottom up (i.e. be voluntary and pre-competitive). But in the short term any such initiative is unlikely to deliver benefits for any one company or even one industry. Hence, there is a clear need for dialogue between sectors and for public-private partnerships.

Vanguard – an effort to better align regional smart specialisation strategies involving 30 European regions – is an example of moves towards large-scale federating platforms. It is aiming towards a scenario where each region is able to use the same type of manufacturing environment, so as to encourage 're-shoring' (products being produced locally rather than sourced offshore).

Europe also lacks relevant infrastructure to exploit platforms effectively. For example, the amount of data that can be generated by a single aeroplane journey vastly exceeds the available storage and analytical capabilities. Yet it is not clear whether industry is ready and able to invest in this area.

Bridging the Gap and Addressing the Issues

A key factor in establishing successful digital platforms is demonstrating added value. The platforms have to meet – and be shown to meet – the needs of their stakeholders, especially the users. This means a strong emphasis on validation, demonstration and experimentation in realistic settings (labs, testbeds, pilot lines, factories). Moving from the laboratory into realistic facilities creates trust and confidence for all concerned – large enterprises, SMEs and users. However, for SMEs especially the levels of investment have to be comfortable – a key role for the digital innovation hubs.

At a technical level, interoperability and integration of legacy systems should be a key focus for testing and validation efforts. This is especially important in the context of federating initiatives where activities seek to build on what has gone before ('a brownfield approach'). Such an approach is being followed in the five large-scale pilots being launched in IoT. These will be multi-stakeholder efforts from the outset so as to create trust and confidence across the community.

Initiatives must also reach out to engage with SMEs, startups and entrepreneurs. Like other stakeholders, SMEs will engage if they see and understand the benefits: competition, new customers, price advantages, etc. Specific measures – spaces, support projects – will be needed for this and should be part of concrete actions.

Although a potential focus on a single platform could be an attractive approach, it also has risks. Focusing all our efforts on one platform – or at least on one platform ecosystem – risks hampering innovation and may deter companies from committing their best efforts. Competition between platforms is generally a good thing.

The legal regime is also important, for issues such as IPR. All players need to be able to compete without giving up their data or paying fees that would be incompatible with their business model.

Main Stakeholders Involved

There is a risk that the segmented sectoral and national initiatives develop in isolation. This must be avoided at all costs. Europe cannot afford an Industry 4.0 with a national flavour or a specific sectoral orientation. So we have to break down silos and circumvent building 28 national systems.

The PPPs should be encouraged to align their strategies and follow through in terms of implementation so as to exploit synergies and find new approaches. Similarly, while we should continue to build ecosystems at national/regional level, interfaces between them will need to be defined at European level. Convergence of national initiatives at policy level should also be encouraged. In effect, we have to aim **towards platforms that know no borders**.

There are clear and tangible opportunities in areas such as:

- The Lighthouse Project, large-scale pilots being launched under the Big Data Value PPP
- Innovation Spaces, a Big Data Value PPP initiative to promote cross-sectoral sharing of data in very secure environments
- Innovation Hubs within AIOTI; and
- Large-scale pilots foreseen in the 5G PPP.

The PPPs represent the views of industry and will be very important in taking the digital platforms initiatives forward.

Requirements for digital infrastructure investment are considerable and the responsibilities for this are unclear at present. It is equivalent to the railroads of the nineteenth century. The private sector appears to be waiting for the public sector to take the lead.

Annex 2: Smart Agriculture

Smart Agriculture Overview

Ana Cuadrado Galván from DG AGRI set the scene by providing a presentation on the activities being undertaken in the area of 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. A key issue being addressed is the lack of take-up of ICT technologies by farmers. The experts of the Focus Group provided research recommendations and ideas for operational groups to overcome existing barriers on adopting precision farming technologies.

To promote further digitisation, a seminar on data driven business models was organised by DG AGRI where different models were analysed. An example of a "product innovation" data-driven business model is that used by John Deere where data is collected from the agricultural machinery used by the farmer. 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. A Final Report from this event will be published by the end of November.

Following the overview of the Smart Agriculture activities a Working Group meeting was held and a number of questions were posed considering the current landscape in Europe, the vision for the future and what is needed in terms of platform development to support this.

Current European Landscape

It was highlighted that some farmers are already 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 startups and there is involvement from many regional agencies. This has led to the creation of many platforms by startups, 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 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. A number of areas were specifically highlighted:

- **Autonomous Tractors and Combines Harvesters** – Autonomous farm machinery is already commercially available, e.g. from John Deere and 365FarmNet, and due to the more relaxed safety considerations with respect to traffic it is possible to have much higher levels of automation than 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 have to contend with multiple platforms with little or no interoperability between platforms. This is becoming an increasing issue.

Vision for the Future

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 help tackle volatility 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.

The future vision places the farmer at the centre of collecting and processing of data. This can be used internally by the farmer for efficiency and optimisation, but also externally to provide better public services and tools to mitigate climate change. In order for this to be possible farmers need to control access to data from the farm and must also be compensated for use of this data to provide an incentive for sharing. To support this change they 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 what it is to be used for by external parties. Here there is a need to build trust and partnerships.

What kinds of next-generation platforms are needed?

The key requirements are for interoperability and standardisation. This needs to be provided without vendor lock-in. The farmer needs 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.

What kinds of large-scale federating initiatives are needed?

There is a big opportunity to gain benefits through data sharing amongst farmers. A lot of data 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.

Ideally data should be stored on a central server that can be accessed by different stakeholders and there is also potential value in making it available externally. 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 this case the model should be subscriber based and needs to be scalable. Barriers to this at present are data ownership and in identifying how to create value from data. There are also some legal and technical limitations. In particular, there is a need to protect the ownership 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.

What concrete gaps/problems could be addressed through platform development and large-scale initiatives at EU level?

There is a key need for interoperability and standards for connecting platforms. Here there is a need for consensus on platforms and cross sectorial compatibility. 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 cost benefits from adopting platforms as farms are operated more like factories. Within Europe the size of farms differs considerably. In France, for instance, there are many smaller farms and here there are different requirements with a market for low cost web services.

Addressing the Underlying Issues

Four key underlying issues are 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.

Smart Tractors and Combine Harvesters

There have been big 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. An issue here is that increasing amounts of data are 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. Already in the US there is a law suit from farmers against SAP as they moved collected farm data to the cloud without permission. Security is also an issue with respect to data.

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. The approach being promoted by the BDVA is to use I-Spaces (Innovation 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.

Overall the use of Large Scale Pilots, such as those being proposed in the IoT area and also being considered by the Big Data Value Association, 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 as 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 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. 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 no matter size and sector.

Bridging the Gap and Addressing the Issues

Already platform building initiatives and Large Scale Pilots are being proposed and more information on these will be available in January 2017. 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 trialled.

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 significant data and there is an opportunity to build a platform using this data that is accessible to farmers.

Main Stakeholders Involved

PPPs can contribute to building platforms via creating a consensus on cross sectorial platforms. Here there is already a BDVA task force. One area where BDVA may be able to support activities is via European Innovation Spaces which have the aim of providing a place to store data that can be used across borders and sectors. Existing initiatives such as AIOTI is mapping national initiatives into sectors and at a regional level there are initiatives such as in Galicia where Public Procurement of platforms is being used for better management of subsidies. There are also university initiatives in the Netherlands on precision farming. At a European level there is a need for collaboration between IoT, Big Data, etc. There is also a need to provide more widespread rollout of Rural Broadband for connectivity.

Key Messages

The meeting provided a number of key messages. The farmer needs to be at the centre of development and should be intimately involved in order to create useful platforms. Currently there is fragmented development of platforms across Europe and to maximise potential there is a need for a co-ordinated strategy rather than many individual initiatives. For this there is a need for liaison across DGs and Member States to come up with integrated solutions and an appropriate supporting infrastructure. There is a big opportunity for Europe in smart agriculture as it is currently a leader in the domain and is seen as the “silicon valley” of agriculture.

Notably concepts from the Circular Economy match well with the sustainability goals of farmers in order for them to be competitive and produce a profit line. They are intrinsically driven to produce more with less addressing concerns about minimising water leakage, use of fertiliser and in meeting animal welfare goals. Looking to the future there is likely to be greater transparency in how things are produced. Notably currently only 2% of food is directly marketed but this is likely to increase in the future.

Large-scale demonstrations are needed to show the benefits of interoperable platforms and the usage of data within smart agriculture. There is a need to assess how the proposed current and future Large Scale Pilots address the issues highlighted in this report. Finally, engagement with farmers is essential and there is a need to consider how best to involve farmers that are already making sustainability improvements to encourage them to exploit digital platforms to make even greater efficiencies.

Annex 3: Industrial Data Platforms

The emerging data economy presents many challenges for Europe. We must seize the opportunities provided by the data economy for higher growth, more and better jobs, better-quality and more personalised products and services. We must boost Europe's capabilities to embrace the potential of the data economy in all sectors. And we must preserve European values, for example in relation to personal information protection and multilingualism.

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

- Community-led sector-specific (vertical)
- Community-led cross-sector (horizontal)
- Commercial 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. Industrial data spaces 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 could provide the technical infrastructure allowing data to be shared with the players that make best use of them while respecting the rights and interests of the party that has invested into the collection of the data. They will be crucial for the digitisation of industrial production.[7]

In the context of the DEI, the aim is to support the development of competitive data platforms and the availability of world class data infrastructure in Europe. The data platforms should ideally be open to members willing to adhere to the rules of the platform. Public intervention for first production and deployment of technology may be essential.

Current European Landscape

Several interesting examples of Industrial Data Platforms were noted.

The Industrial Data Space (IDS) initiative was launched in Germany in 2014 by representatives from business, politics and research. It aims to develop and pilot test a reference architecture model for a secure virtual data space using standards and common governance models.[8] It thereby provides a basis for creating and using smart services and innovative business processes while at the same time ensuring digital sovereignty for data holders over their digital assets. The initiative has since evolved into two strands, a research project and non-profit user association with membership in other European countries.

[7] See the report: Industrial Data Platforms – Key Enablers of Industry Digitization European Data Market SMART 2013/0063 D 3.10. Available at: Available at: https://docs.google.com/a/open-evidence.com/viewer?a=v&pid=sites&srcid=b3Blbi1ldmlkZW5jZS5jb218ZG93bmxvYWR8Z3g6NjIiZTQ1NTYyZjdlOGNhNg

[8] Outlined in the White Paper: *Industrial Data Space: digital sovereignty over data*, www.fraunhofer.de/content/dam/zv/en/fields-of-research/industrial-data-space

An example of a commercial platform 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, enabling them 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, for example.

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

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.

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.

Vision for the Future

Legal issues are key to the future development of Big Data. Handled correctly they could be an enabler for the whole data economy in Europe; or they could hold it back.

Sharing data is not as easy as people think. There can be no copyright on sensor data and thus questions of ownership often arise in sensor-intensive applications such as agriculture and healthcare. The issue of ‘data ownership’ in such situations is increasingly controversial. With a factory machine, for example, data may be collected and shared for various purposes (e.g. preventive maintenance) between several parties: the owner of the machine, the manufacturer, the lessor, etc. The legal regimes can be time consuming. In any case, many lawyers would argue that there is no such thing as ‘data ownership’: from a legal point of view there are just the competing rights of different parties to access, store, transform, license, etc. data.

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 contract templates so as to ensure that the interests of the various parties are protected and without any party taking exclusive rights (which in turn could lead to rents). The more technically precise the specification, the easier the legal contract becomes.

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 this data constituted a valuable resource: one potential market was with local vets. 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.

It was noted that under the IDS framework data owners retain legal sovereignty over their data; a connector is attached to data that is shared. There are guidelines on this issue, not a technical solution at the moment.

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, due to removing the middleman from many transactions. One advantage is that, by avoiding the need for a central point of coordination, Blockchain offers a more transparent market in all forms of contracts. For example, in telecoms, there would no longer need to be 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.

Bridging the Gap and Addressing the Issues

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 iSpaces and Lighthouses will be important here.

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.

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. 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.

Main Stakeholders Involved

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

Most platforms will be vertical to some extent. The options are essentially two-fold: the foundation/ association approach (as with IDS); and the provider ecosystem approach (as with Siemens MindSphere and automotive platforms). There need to be justified reasons to intervene in the market, going beyond R&D and demonstration.

High level management of private companies needs to be involved to ensure take up of digital technologies. Governments also have a role. However, there are few visible examples from the Member States at present; these need to be publicised more.

Finally, it was noted that data on workers has no status under European law. We must be careful that personal data collected on workers does not become conflagrated with data collected on machines: the two must be kept separate.

Annex 4: Internet of Things

Current European Landscape

A study of existing platforms around the world by the Unify-IoT project had identified around 360 known platforms, with the vast majority of these being developed from 2013 onwards. The initial explosion of new platforms and SMEs in the area was, however, slowing down which is a sign of a new immature market. 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 have the resources to dominate the future market. Google, for instance, has bought up a number of robotics companies recently. A notable difference identified between Europe and the US is that there are less barriers to deployment in the US. Another notable difference is that within Europe there is a generous culture towards international 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 was better and there was 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. It was noted that the rise of the circular economy may offer some opportunities for linking the consumer market to capture use information for 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 are essential to give SMEs access to new technology and leverage the dynamics of new ways of making business as proposed by startups.

Siemens strongly pushes the vision of a web of systems approach for interconnection between many devices; 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 and also the term "Things" as it does not adequately describe systems. The company has a much stronger focus on the World Wide Web and services. The need for security levels was advocated.

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 startups, 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.

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 addressing 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. Digitisation of European Industry, FoF, ECSEL (ARTEMIS-IA, EPoSS, Aeneas), and Industrie 4.0 are supporting a number of IoT-related 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 AIOTI is becoming a legal entity to allow it to establish liaisons with other groups.

Vision for the Future

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 for supporting standards as a key element of platforms. Looking to the future, next generation platforms should address 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 European Union has a role to play in providing data governance that supports European values.

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. Bosch, 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 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 startup community (as it is the case in the U.K.) and access to finance within Europe to create platforms.

Bridging the Gap 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. The following areas were considered key:

Platform Building - Connecting Regional and National Initiatives across Europe

Already there is a zoo of platforms and there is a clear need for convergence. This needs to be driven by market pull and the opportunity for Europe is in strength 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 being 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.

Actions 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. By bringing the ecosystem together, e.g. by linking European projects focussed on autonomous driving for instance: 5G, ECSEL and the IoT LSP, 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 and so there is a need to address interoperability between 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 build on Industrial Partnerships as this will lead to successful exploitation and accelerate market up-take. Already there are many IoT platforms and there are growing partnerships such as the IIC and the alliance AIOTI. However, there is a need to promote a more intense dialogue across a critical mass of stakeholders, including large companies as well as SMEs, and promote consensus on platform up-scaling. This can be strongly supported by the AIOTI alliance with the aim of bringing different communities together. Here there is a need to discuss legal issues, technical bottlenecks and market barriers. 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 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 startups 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. As highlighted Europe is strong in connectivity but weaker in the area of Internet platforms and Big Data analysis where there is potentially more added value. 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.