Digital Manufacturing Platforms for Connected Smart Factories

Report from the Workshop on
Digital Manufacturing Platforms for Connected Smart Factories

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Disclaimer: The views expressed here are those of the workshop participants and do not necessarily represent the official view of the European Commission on the subject.

Executive Summary

The Workshop successfully brought together experts from the manufacturing domain to discuss the use of platforms in Digital Manufacturing. The Digitising European Industry initiative is driving the development and uptake of platforms; however, in order to take this forward a number of key needs were identified:

- **Reference Implementations Demonstrating Interoperability** - Reference implementations are needed to demonstrate the power of platform approaches to industry. Piloting is seen as very beneficial to gain acceptance for new technologies and also in supporting the development of standards. It is clear that connectivity and data will drive the future and to support this there is a need for open platforms that support interoperability and data exchange.
- **Changing Mindsets and Creating Digitisation Skills** – The human is a very important element of the future manufacturing ecosystem. It is important to take this into consideration in collaborative business environments. There are different cultures, e.g. family owned businesses, and different levels of skills and competences. In order to change and adopt new ideas for digitisation the right mind set is required along with the necessary development of digital skills. This needs to be combined with education on security as the human at present tends to be the weak link within the system.
- **Growing an Ecosystem** – To successfully digitise industry there is a need to develop a supporting ecosystem. Provision of open source software, supporting toolkits and standardisation make integration and uptake easier but a key challenge is to convince companies at a national and local level to engage in digitisation. Here the Digital Innovation Hubs have a crucial role to play combined with the use of other incentives to encourage companies to digitise.
- **Sharing of Experience and Collaboration** – The meeting highlighted that there are many activities at the national and European levels that are contributing to digitisation. It was also notable that many developments had been made as a result of continued research and development building upon previous project outcomes. To avoid development taking place in silos there is a need to share experience and collaborate.

While it is clear that there is some confusion within the industry about what the term “platform” means it is clear that an “operating system” type platform is needed in manufacturing internally within organisations, and externally to connect together organisations in collaborative networks. At the external level this also needs to be supported with economic B2B platforms. The industry is challenged by the fact that there are drives for process optimisation, increased flexibility for customised production, and there is a move towards dynamic manufacturing via networks of SMEs. Technology is changing at an exponential rate with many new innovations in Cloud computing, edge computing, blockchain, Digital Twin, etc., which support these new agile manufacturing needs but at the same time result in fundamental changes to the automation pyramid. The growing gap between the exponentially changing technology and implementation by organisations requires support at a European level both to adopt new technologies and to re-skill in order to maximise the benefits of exploitation.

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Introduction and Scope of Meeting

The objective of the workshop was to discuss what future-looking digital manufacturing platforms would need to be addressed, developed and piloted at EU level, taking into account previous and ongoing activities, as well as opportunities for the future. New technologies such as the Internet of Things (IoT), Cloud computing, 5G, Big Data and data analytics, robotics, artificial intelligence and 3D printing open new possibilities for industry to become more competitive and more efficient with improved processes, innovative products and services. In support of this in April 2016 the European Commission launched the Digitising European Industry (DEI) initiative which builds upon and complements various national initiatives for digitising industry. The aim is to use policy instruments, financial support, co-ordination and legislative powers to trigger further public and private investments in industrial sectors and create the right framework conditions for industry to grasp the opportunities of digital technologies.

As part of the DEI implementation a working group was tasked 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 could contribute [1]. Vertical sectors were considered: Connected Smart Factories, Smart Agriculture, Digital Transformation of Health and Care, as well as the horizontal topics of Industrial Data Platforms and the Internet of Things. This resulted in a Focus Area in the R&I Horizon 2020 work programme 2018-20 on platform development, large-scale piloting activities, ecosystem building and standardisation with a budget of 300 MEuro.

In the specific call on Digital Manufacturing Platforms for Connected Smart Factories proposals are being sought that target at least one of the following “grand challenges” that have been defined by the Factories of the Future Public-Private Partnership [2]:

- Agile Value Networks: lot-size one
- Excellence in manufacturing: zero-defect processes and products
- The human factor: human competences in synergy with technological progress
- Sustainable Value Networks: manufacturing in a circular economy

A previous workshop on “Platforms for connected Factories of the Future” that took place on 5-6 October 2015 gave an overview of existing activities on manufacturing platforms. In autumn 2016 ten projects were initiated under the FoF PPP to develop reference implementations of platforms in multi-sided market ecosystems considering factory automation, collaborative manufacturing and logistics. In addition, the ConnectedFactories Coordination and Support Action was funded to identify future needs and challenges for digital platforms. A goal of the workshop was to highlight the effectiveness of various approaches that have been undertaken already and further understand what digital manufacturing platforms should be developed and piloted in future.

Host’s Welcome (Željko Pazin, Chris Decubber, EFFRA)

The meeting was opened by Željko Pazin of EFFRA who highlighted that digital platforms in manufacturing will be very important for the future and this is why it is a hot topic at national and European levels. It is clear that platforms will result in change. From the perspective of factory managers, they see platforms as a service that they can buy in the same way that they can buy supply of electricity. However, experience shows, e.g. booking.com, how

software platforms can revolutionize an industry by introducing new business models. One challenging aspect for the manufacturing sector is to predict and evaluate the magnitude of this change.

Introduction (Max Lemke and Arian Zwegers, European Commission)

Arian Zwegers provided an introduction from the European Commission highlighting the difficulty in exactly defining what a digital manufacturing platform is as the concept means different things to different people. This is analogous to a group of blind people trying to identify an elephant by each, touching different parts of the elephant's body. This can lead to many different interpretations. As a consequence in the new manufacturing call in the area of platforms the call text has deliberately been left open to allow industry to decide what key innovation needs to be done.

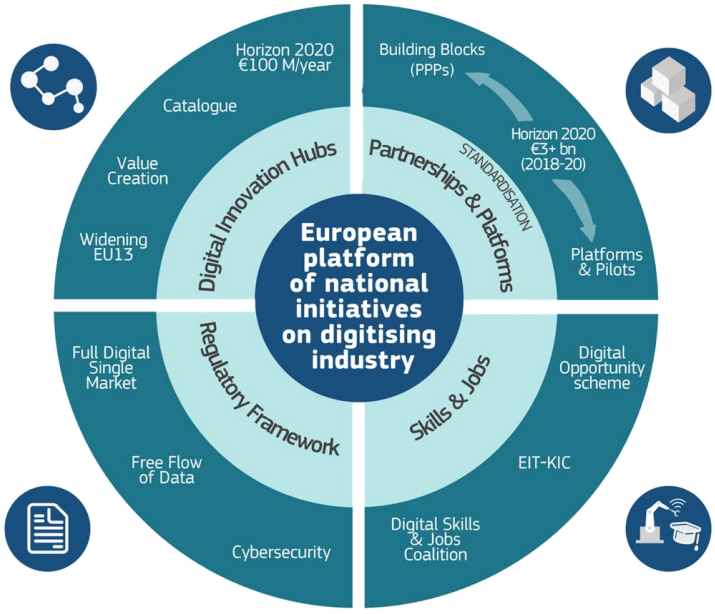

Figure 1 Digitising European Industry

An overview was given of the Digitising European Industry strategy. This addresses research and innovation, development of skills via, amongst others, the European Institute of Technology and Digital Innovation Hubs, the regulatory framework considering the free flow of data between member states, and also standardisation. A large part of budget is being placed into building blocks that together make up a Digital Value Chain. These blocks are expected to form the basis of technologies, such as AI, Big Data and Cloud computing, and are also used in applications such as autonomous driving, smart factory and healthy ageing.

With the advent of the digital revolution, products and services increasingly combine different digital technologies. For instance, autonomous driving integrates vision systems, robotics, artificial intelligence, mobile communication, and more. To build such autonomous vehicles, one needs both technology building blocks such as robotics components, artificial intelligence modules and mobile communication systems, and at the same time the means to integrate those building blocks into applications. This requires some kind of middleware. If you then add standard services such as data analysis and context awareness, and if you

open up the interfaces to third parties, you create a platform. Such digital industrial platforms integrate various functions implemented by different technologies via clearly specified interfaces, and make data available for use by applications.

It was noted that the EC is not interested in online platforms such as Facebook or in creating platforms in the interpretation of “discussion forums” as for instance in “Plattform Industrie 4.0”. The key interest is in creating a kind of “operating system” that integrates different technologies and various applications/services. Platforms can also have different roles, with emphasis on providing support for a Network or Community, providing a Technology Infrastructure, or providing integration of Data. Some well-known online platforms exist in the consumer world that fill these roles to varying degrees such as the Airbnb marketplace, Android operating system, and the webMethods integration platform/middleware. What is really needed in smart factories is something analogous to a smartphone operating system that provides an interface to different hardware on which Apps can be built and executed. There are already examples of platforms that are community-led, sectoral platforms such as AUTOSAR, ISOBUS, and FITMAN, as well as community led cross-sector horizontal platforms such as S3P, Industrial Data Space, CRYSTAL, FIWARE and ARROWHEAD. Some commercial manufacturing platforms with open interfaces exist, e.g. MindSphere, etc.

A key aim is to align R&I efforts in digital industrial platforms and here people need to join forces along common interests, with the aim of creating future global standards and platforms that are driven by the interests of EU actors. This can be done by integrating key technologies that are being developed in digital industrial platforms, reference architectures, reference implementations, large-scale pilots, and experimentation environments. In support of this there is a need for ecosystem building and standardisation. Federation between different developments from different programmes and initiatives is required and this is a theme of the Focus Area on Digital Manufacturing Platforms. Similar platform building initiatives will be supported in smart agriculture, smart hospitals, smart homes and grids, with also some preliminary activities in the construction sector. The 4 Grand Challenges taken from the EFFRA document “Factories 4.0 and beyond” are being used as drivers for the Connected Smart Factories area and a goal is to support reference implementations which can be piloted and further validated by budget reserved for third parties. Work should address platforms, pilots, ecosystems and standards. The formal call was launched on 31 October 2017.

Max Lemke highlighted that the EC has been working strongly with EFFRA. The manufacturing sector is more advanced in preparations with activities such as ConnectedFactories, the development of the Reference Architecture Model for Industrie 4.0 (RAMI 4.0), the Industrial Data Space and several commercial platforms already existing. In the upcoming call, proposals are expected to achieve broad impact, as narrow proposals only tend to benefit a few companies, and a much smaller number of strategic proposals are being sought. The aim is to build on existing developments and use European money to pool around these activities addressing all of the following: platform building, piloting, ecosystem building and standardisation, in order to create impact. The aim is to stay open, i.e. not prescriptive, and to be strategic to avoid oversubscription of proposals. Ideally proposed pilots should be in more than one sector with implementation across member states. They should also be supported by work on business models, where for instance the impact on business models of technologies such as blockchain could also be considered. A goal is also to create reference implementations, preferably in open source. These may be open source but not necessarily, as long as this can be argued for. The call closes in April 2018 which gives time for strategic proposals to be put together.

ConnectedFactories scenario building exercise, mapping, first analysis (Chris Decubber, EFFRA)

The aim of ConnectedFactories is on the one hand to connect research and innovation to create digital manufacturing platforms and on the other hand to identify industrial pathways that lead to enhanced connectivity in manufacturing. The ConnectedFactories consortium is composed of research and technology organisations (RTOs), industrial associations and universities, all of which are very active at the European, national and regional levels. Consortium members are directly connected to large national initiatives in Germany, France, UK, Spain, Italy, Belgium, Sweden, Finland, the Netherlands as well as others. ConnectedFactories engages with the local level through yearly national/regional workshops, identifying challenges and requirements, while at the same time looking for the pathways to deployment. Here the project is looking at digital manufacturing platforms that support a variety of processes, such as for instance smart maintenance, etc., as well as supporting business models. A digital mapping framework is being used to structure the analysis and exchange of information and an associated Structured Glossary has been created. The project is also looking at standardisation, security, liability, social aspects, and skills. A "Scenario-Building Workshop" was held in September that discussed draft future visions, explored possible pathways and practical implications. Four "personas" were defined around user types and application scenario's: Hyperconnected Factories, Autonomous Factories, Collaborative Product Service Factories and Small Scale Digitised Factories. On-going projects and commercial solutions are being situated within each of these personas. Linkages have been formed with other PPPs such as the Cybersecurity PPP, ECSEL, 5G and BDVA.

Baseline results from ongoing projects

A session was held to identify what results are available from past and ongoing projects which could be used as the basis for future projects. The session also identified areas that need to be addressed in the future.

FAR-EDGE (Mauro Isaja, ENG)

FAR-EDGE is a joint effort from experts in the manufacturing, industrial automation and Future Internet technologies areas, towards the smooth and wider adoption of virtualized factory automation solutions. The aim is to move computing power to where it is actually needed offloading a data centre or Cloud and spreading the workload to edge nodes and gateways with a consequent reduction in data transfer. While the approach offers advantages it is more difficult to manage as it decentralises process control and analytics. The aim of the work is to virtualise the conventional automation pyramid moving the IT backbone to the shop floor, splitting it into semi-autonomous units placed in charge of local field equipment and processes. These are integrated into the global process which is stored in blockchain technology to avoid a central bottleneck. A Reference Architecture has been produced for smart factories with Open Platform Specifications. Currently a Reference Implementation is being created in the lab which will then move to industrial plants. KPIs on cost effectiveness and scalability will be produced. The ledger used to synchronise and orchestrate local Edge Processes across the factory is based on the HYPERLEDGER open source software. RTE standards for Edge Automation Services and the Edge Analytics Engine have been proposed. All outputs will be made available open source in Q1 2018. Pilot ledger services will also be made available for people to look at via a smart contract lab. A link with FIWARE is also planned.

CREMA (Stuart Campbell, ICE)

CREMA aims at simplifying the establishment, management, adaptation, and monitoring of dynamic, cross-organisational manufacturing processes following Cloud manufacturing principles. The project has been going for 3 years and will finish this year. The key aim is to provide easy access to Cloud services and ubiquitous computing moving to a pay-per-click model. This takes Cloud concepts and moves them into Cloud manufacturing via virtualisation of manufacturing of assets. This will allow external access to get information from machinery, e.g. injection moulding machines, either for maintenance or to flag their availability for use if not currently occupied. This allows production to be moved from one place to another either at the intra- or intercompany level. A Plug and Play API environment is used in a service approach to connect processes and virtualise manufacturing assets. This is supported by a marketplace, pay-per-click support, and tools for collaboration and analytics. Everything is open source via Apache and all specifications are public. A business plan has been created and a start-up CREMAnufacture will launch in 2018.

vf-OS (Stuart Campbell, ICE)

vf-OS will provide a virtual factory Operating System (vf-OS) and Software Development Kit (OAK) for Factories of the Future. It aims to be the reference system software for collaborative manufacturing and logistics processes. It will provide a process execution engine and connections to external peripherals, device drivers, APIs etc., and middleware for storage of data to a hard disk. An SDK, control panel, dashboard, front-end, and developer hub are also being provided. In addition, the project is providing a platform marketplace, training and support for integration. Implementations will be made in line-manufacturing and construction applications. Both on-premise and Cloud variants are being explored. For

development a hybrid agile approach is being adopted. Everything from the project is being made public with a documented API and open source code.

ECSEL JU Lighthouse Initiative Industry4.E (Berta Ferrer Llosa, ECSEL JU)

Two lighthouse initiatives are being defined by ECSEL: Mobility.E and Industry4.E. A lighthouse is a container of co-ordinated activities, e.g. H2020 projects, national projects and ECSEL funded projects, working together towards common goals. A group of 4 experts called LIASE has been set up to formulate a focused roadmap for the lighthouse which also liaises with stakeholders and invites other projects to join. The lighthouse is independent of ECSEL but is supported by it. An aim of the Roadmapping exercise is to identify coverage and overlaps in work but also to identify gaps. It was noted that there is a strong cooperation with the ConnectedFactories project.

Productive 4.0 (Knut Hufeld, Infineon)

The main objective of Productive4.0 is to achieve improvement in Digitising of European Industry by exploiting electronics and ICT. Ultimately, the project aims at suitability for everyday application across all industrial sectors up to TRL8. It addresses various industrial domains with one single approach to digitalisation. What makes the project unique is the holistic system approach of consistently focusing on the three main pillars: digital automation, supply chain networks and product lifecycle management, all of which interact and influence each other. The project brings 109 partners from across Europe covering the ECSEL communities AENEAS, ARTEMIS-IA, and EPOSS. Pilot lines will be performed in automotive, machinery, robotics, semiconductor and electronics, consumer, automation and logistics. There are also mergers between domains with work on Digital Production, supply chain networks and product life cycle management. The lighthouse is organised into workpackages which are moving towards reference implementations. Each workpackage has objectives and expected results. Gaps in standards are also being identified which will be highlighted to SDOs. Applications include autonomous flying robots at BMW for assembly lines, supply chain management at Bosch, and smart services for manufacturing at ABB.

Boost 4.0 (Oscar Lazaro, Innovalia)

Boost 4.0 is one of 4 Big Data lighthouse projects looking at Big Data Value spaces for Factories 4.0 and specifically addresses the role of Big Data in development of factories. Manufacturing as a sector accounts for 15% of GDP and Big Data has a major contribution to make to this in the future. The project has not officially kicked off yet and will start on January 1st next year. It brings together 50 partners in 16 countries. The aim is to build pilots with real technology that will provide measurable benefits for industry. The aim is not to deliver one Big Data platform but to bring together stakeholders to create an ecosystem. The key challenge is that there are lots of actors and there is a need to work in compliance with global standards, such as RAMI 4.0, etc. SMEs are an important part of the ecosystem and outreach will be performed via the DIHs. A holistic approach is being adopted to cover the data value chain, perform pilots, and to create a Big Data Framework. A key aim is to build a model for connected smart factories based on platform integration, common open data models and APIs. 10 pilots will be performed covering areas such as smart digital engineering, smart planning, smart operations and digital workspace, smart connected production, smart maintenance, and services. Overall the pilots will demonstrate 40 new manufacturing processes. There is a strong influence from the automotive sector (6 out of 10 pilots are in this sector), however, there are also pilots in the white goods and machine tool sectors. The project is looking for replication in the textile and ceramics industries and also in more regulated sectors, such as aerospace.

Industrial Data Spaces (Egbert-Jan Sol, TNO)

Industrial Data Spaces is driven by Fraunhofer and there are now 78 companies involved across Europe. The initiative is also expanding into the US and Japan. To provide greater coverage linkages are also being formed with national organisations such as Tecnalia in Spain and SINTEF in Norway. The aim of Industrial Data Spaces is to provide a secure data space which provides “Sovereignty” over data. The plan is to get the concept standardised by RAMI and the IIC. Here open standards will be enforced with the aim of allowing access for SMEs. It was noted that the Industrial Data Space goes beyond manufacturing and also covers other sectors as well such as the Pharma sector.

Industrial Platform Approaches

In this session vendors were invited to highlight their digital manufacturing platforms and the trends that they see in the market. The needs for the future and how technology providers cooperate with other providers were also discussed.

Bosch-Rexroth (Johan Peeters)

The presentation highlighted how Bosch is implementing Industrie 4.0. The company has a wide diversity of business activities covering automotive sensors, consumer goods, building heating and security, industrial technology for automation, packaging, etc. Bosch is driven by trends and these include the advent of low cost sensors and the next industrial revolution – Industrie 4.0. There is a need for fast and flexible integration and to achieve this open standards are required. In support of this there are activities addressing the Digital Life Cycle and also the use of Distributed Intelligence. The company has been working closely with Industrie 4.0, IIC, DRC China, and BITKOM in Germany. Internally there is a dual strategy as Bosch is both a leading supplier and user of technologies. This allows the company to experiment with new technologies in its own factories. The company provides software, solutions for logistics and manufacturing, field equipment, services and consulting, and covers the whole value stream. Bosch has its own vision for the Factory of the Future. This includes the introduction of Automated Production Assistants (APAs) that actively assist workers using hand tracking technology and developments in the packaging machinery sector to provide an IoT gateway for connectivity in a simple, flexible way with a view to achieving “plug and run” in three steps. It was noted that an advantage of adding connectivity to machines is that it is possible to gather energy consumption data which can be used for optimisation. Another innovation is the development of “cabinet free” pick and place packaging lines to reduce carbon footprint. The company is also very active in intelligent motion control and develops software, such as the Active Cockpit Dashboard, which is used for displaying key data on displays and tablets. It was noted that although many new technologies already exist, in order to exploit them factories need a fast internet connection and the use of wireless communications is still not well established in the domain. The company has many collaborations with partners, e.g with Dassault on the packaging of beer, and for this it is important to use open standards. The need to collaborate with users, customers, subsystem integrators, suppliers and the research community was highlighted.

Dassault Systèmes (Hadrien Szigeti)

Within Dassault the 3DS initiative is contributing to the development of Digital Manufacturing Platforms. It was noted that this requires people, business and innovation to come together and this is depicted on the “compass logo” that the company has launched. The company has traditionally been seen as being closed but now it is trying to be very open, however, this is not, as yet, well known. The company is very interested in open innovation and education. A number of key challenges have been identified such as cities for the people, resources and energy, global personalised health, etc. It was noted that the top ranked companies have changed from the more traditional companies of a decade ago to Apple, Google and Microsoft today. In terms of business models there has been a shift from pipes to platforms and all the key players are now matching customers and suppliers on a platform. Dassault thus want to provide a platform to connect disciplines inside and outside of companies. They are not only considering an “operating system” inside of a company but an “operating system” outside of the company as well. The company is actively working on simulation, design, project management, optimisation and prediction. Examples of this are the Virtual Singapore project which is creating a digital model of the city for other service developers to use and HomeByMe which allows people to create a model of their house and visualise how

furniture will look. This supports the furniture industry which today tends to work on a demand lot of one. A key problem is that industry is way behind on using a platform approach. Organisationally people need to think differently and there is a need to unlock organisations. Open innovation is required and here Dassault has created the 3D Experience lab where companies can use a platform without having to rent or buy it. Dassault provides coaching (10% of an engineer's time) if the ideas being pursued are considered worthy by upper management. JOBY and TESLA are already using this facility. There is also a lot of activity in virtualising products before real implementation. Here there is a need for new business models and creation of a market place. An example would be to allow designers in SolidWorks to be able to get in touch with all the people who have a 3D printer that can provide a quote for a designed part. Another key need is to create an ecosystem and here the "Human to Human" factor is very important. To support education Dassault has created Peer Learning Experience Professors around the world. This is being provided for free to 130 Professors to provide them with teaching materials for their students. This concept is also being considered as a service that could also be sold to industry.

SAP (Nemrude Verzano)

It was highlighted that SAP originally started off as an accounting solution provider but it is now doing a lot more than this including looking at the use of wearables in production lines. It has moved into a variety of sectors such as automotive and aerospace. Currently, it is moving into the sports and entertainment sectors. There are interests in the paperless factory, cobotics, extracting manufacturing insights, and in providing flexibility. It was noted that Industry 4.0 is picking up speed and this is leading to distributed manufacturing and the flexible provision of manufacturing services such as 3D printing. It was highlighted that sectors that are normally slow to take up new technology, e.g. the forming industry, are also becoming more receptive to new ideas. The SAP Leonardo software was highlighted and there are a number of functionalities of interest for the future such as machine learning, blockchain, Big Data, Internet of Things, analytics, and data intelligence. Big Data is important for generating transparency and predictive insights which enable decision makers to make proactive corrective actions. It was noted that everything is being connected in the factory and ultimately this is connected to engineers, sales and orders. Currently Digital Twin is a big driver in the sector and this needs a closed-loop engineering approach. Standardisation is a key missing element and SAP is working on the Administration Shell from RAMI. Of key interest to the company is to find ways to integrate other people into the SAP environment.

Grand challenges and future digital manufacturing platforms

Different company strategies may lead to needs for different manufacturing platforms. EFFRA has identified Grand Challenges as recommendations for the H2020 Work Programme 2018-20. In this session key actors where asked to present their perspectives on the grand challenge areas and how these relate to future digital manufacturing platforms.

Agile Value Networks: lot-size one (DIGICOR – Arnd Schirmann, Airbus)

It was noted that in the aerospace industry there is a need to support legacy products such as existing aircraft while at the same time supporting new products via agile networks. Traditionally the sector has used strongly OEM controlled platforms but this presents a high burden for newcomers to join the supplier base. The DIGICOR platform offers a technology platform, collaboration tools and services that allow manufacturing companies and service providers to create and operate collaborative networks across the value chain. The platform supports the integration of non-traditional, small, but innovative companies into the complex supply chain of large OEMs. Governance rules are used to reduce the burden of setting up collaborative networks and shorten the time to jointly respond to business opportunities. The vision is to have agile networks that allow the development of novel mobility products, such as personalised flying vehicles, with a short turnaround. For this, traditional aircraft manufacturers want to team up with newcomer start-up tech companies. This requires an open platform for collaboration so that demonstrators can be put together very quickly. Using an agile approach it is possible to put contracts together in a few days. It was noted that many small companies are family owned which is a very different dynamic. One area where it is possible to integrate agile suppliers into a legacy supply chain is to allow sharing of 3D printing capacity. The company has been pursuing this concept with a demonstrator of an SME logistics packaging service. The idea has been extended to the Wales SMECluster portal and the platform currently considers 150 companies. However, it was noted that Airbus itself has links with 6000 SMEs and there is a need to connect everyone via the platform. Here it is necessary to provide linkages to a number of existing platforms operating at a regional level that SMEs use. It was highlighted that a license fee model is not appropriate when there are only short-term connections and so another business model is required. Looking to the future there is a need to look at cross-platform collaboration, regional platforms, integration of services, novel business models and demonstrators. It was noted that the added value of digital factory data exchange for an SME is at the platform level.

Excellence in manufacturing: zero-defect processes and products (ZERO-DEFECT Cluster of Projects - Jan Post, Philips)

Philips produces 100M shaver heads per year. In the manufacturing of these there is a need to speed up innovation and increase flexibility, while at the same time increasing customisation and reducing costs. In order to develop new products more quickly and introduce innovations it is necessary to do modelling and perform simulations considering materials, forming, heat treatment and finishing as well as considering the physical interaction with the human head. By introducing new approaches the company had reduced development time for new products from 10 years to 1.5 years and it was now no longer necessary to perform expensive experiments. Altogether 111 parties are involved in the Zero Defect Manufacturing (ZDM) initiative which has produced a roadmap, vision and white papers. The initiative brings together a number of projects in the area such as the MIDEMMA

project addressing a “zero defect” approach in micromanufacturing by exploiting extensive process monitoring in 10 different test-cases and the MEGAFIT project which is investigating complex modelling, robust meta modelling and data analytics for sensors in the production system. There has been a change from using experiential knowledge to spectator knowledge by combining modelling with data analytics. It was noted that models and sensor data provide different information. By using real process data and a Digital Twin it is possible to bring model based design to the shop floor. Within the ZDM area there are a lot of cooperations including with ECSEL at the European level via MANTIS and regionally via RoSF (40 SMEs locally), etc. It was noted that a key issue is to transfer knowledge back to the company and shopfloor. For this, it is necessary to recruit people locally and to enable this Philips has defined “landing spots” within the company for people to visit. In the future a digital content platform and a cooperation platform will be needed that provides multi-state, multi-process, multi-vendor open interfaces for interoperability between platforms to combine industrial statistics with a Digital Twin. There are also needs for research on AI, security, maintainable software, and education for workers.

The human factor: human competences in synergy with technological progress (Monika Belgran, KTH)

The work at KTH is targeting Swedish industry and, in particular, interviews and Round Table discussions have been held in Stockholm and Gothenburg on the needs for human competences in digital manufacturing platforms. It was noted that there are hundreds of software systems and as technology changes there are some questions about whether ERP will still be used in the future or not. The advantages of moving from 2D to 3D models have also been investigated as well as how standards and the automation pyramid may be affected in the future. Looking to the future seamless communications will be required. It was highlighted that there are two types of factories: Greenfield and Brownfield, and the reality is that the majority of factories are Brownfield which requires addition of new technology to legacy systems. The life cycle for factories is typically 20 years and so it is important that old and new platforms can co-exist. A consequence is that Brownfield Factories require a lot more change management and this in turn requires a supporting mindset for change. A wrong mindset can adversely affect investments and operations of digital manufacturing platforms. It was highlighted that technology change is growing exponentially via Martec’s Law but implementation on the organisational curve lags behind this. As a consequence there is a gap between technology and implementation and this is growing. The organisation learning curves are also different for large and small companies as each has very different resources and competences. For instance, SMEs still use Excel in many areas and most smaller companies are only considering digitisation for administration. It is necessary to understand how to prioritise change and identify where this adds value. Digitisation is expected to have a big impact on Lean Manufacturing for optimising production. A key concern at the moment is cybersecurity. In the factory environment there is still a lot of old 70’s equipment, and research has shown that many companies find that their employees are dealing with data and security inappropriately. This includes risky activities like logging in from home into factory networks and also bringing in and connecting home computers directly into factory systems. This is compounded by the fact that many companies outsource their IT creating a competence gap within their own workers. Looking to the future there is a need for competent people from engineering to purchasing who understand IT, PLCs, etc.

Sustainable Value Networks: manufacturing in a circular economy (Konstantino Georgoulios – LMS University of Patras)

There are lots of activities going on around the world addressing sustainable and circular economies. This includes initiatives coming from the UN with the aim to “do more and better with less”, the EC with the aim of transforming the economy into a circular one and the US

Chamber of Commerce Sustainability programme which is trying to achieve greater resource productivity. In support of the circular economy the FUTURING project aims to create a framework to support analysis and policy recommendations. The vision focuses on the potential for re-industrialisation in Europe for areas where a circular economy can provide a business case. The project is considering a number of areas: policy and finance, environmental responsibility, science and technology, business and innovation, the human being and safety, as well as education and training. A three pillar structure has been proposed considering plant, people and profit. Based on this three manufacturing areas have been identified: *Value Networks*, *Shopfloor* and *Product Service*. Each of these has been analysed via a RESOLVE process for developing and applying sustainability. In the future there will be a move to dynamic manufacturing networks exploiting CPS and 5G communications, etc., which will introduce far more sensing capability to optimise the process. Looking at equipment decisions there will be a need to decide whether to maintain, refurbish or recycle assets. Going forward digital manufacturing platforms will be needed to support new product service applications. Although the project has an ecology focus it is also considering the societal perspective such as the need for economic incentives.

Elements of future platforms

Building platforms is not enough, they also need to be piloted, validated and standardised. Activities such as piloting, standardisation, and ecosystem building will be important contributors to their uptake. Here links with national and regional initiatives will help with the take-up of new platforms.

Piloting (George Beers, DLO)

IoF2020 is supported by the European Commission with a budget of 30 MEuros. The aim of IoF2020 is to build a lasting ecosystem that fosters the large-scale uptake of IoT technologies across a diverse sector considering farm-to-fork. 75 key stakeholders along the food value chain are involved in IoF2020 together with technology service providers, software companies and academic research institutions. Nineteen use-cases organised around five sectors (arable, dairy, fruits, meat and vegetables) will develop, test and demonstrate IoT technologies in operational farm environments all over Europe. The first results are expected in the first quarter of 2018. The work is strongly supporting FIWARE and is connecting together many existing platforms. It was noted that already there is a lot of interest in the project from the AgriFood sector. In support of promoting uptake of IoF2020 technologies business KPIs are being collected and reusable components are being identified across applications. An open call for new subprojects will be made and this is being devised with input from farming cooperatives and advisory agencies. There is already a strong connection between the Agri and ICT worlds but standardisation and interoperability are key challenges. To encourage uptake use cases are being pursued with a “no excuse attitude” to ensure engagement with end users. The project is looking to create a long-term ecosystem for sustainability and is also cooperating with other similar initiatives.

Ecosystem building (Wernher Behrendt, Salzburg Research)

The digital ecosystem can be described in terms of customers, companies, goods, currencies, energy, and business processes in an analogous way to organic ecosystems. The ultimate goal of the NIMBLE project is to develop a federated, multi-sided and cloud services-based business ecosystem that supports B2B collaboration for industry, manufacturers, business and logistics. The software for a B2B platform for SME supply chains has been created which allows prospective platform providers to engage SMEs in both sectorial and regional specialisations. It is planned to have 2000 companies signed up to the platform by the end of 2019 and demonstrate the federation by connecting at least two instantiations of the NIMBLE platform. In order to be successful the project has defined aggressive targets to double users every quarter in order to achieve exponential growth. To enable this joining the platform has been made as easy as possible via self-serve onboarding and incentives that are being offered for “bringing a friend”. The platform provides functionality for registration, publishing and search, leading to business processes that can be executed once the terms of a transaction have been successfully negotiated. Via the SEED programme the core business services are being given away via permissive open source, to potential platform providers. An open API is also being provided for 3rd parties to develop additional services. It was highlighted that there are more stakeholders in the community than first thought and there is a need to consider both the technology and the economic infrastructure, e.g. banks as mediators to help their SME customers achieve economic success. It was noted that the goal of federation enforces design for interoperation and an open API/open source approach leads to more functionality being offered with less code to maintain.

Standardisation (Franco Cavadini, SYNESIS)

The aim of the Daedalus project is to enable the full exploitation of the CPS concept of virtualized intelligence, through the adoption of a completely distributed automation platform based on the IEC 61499 standard. The achievement of this objective is strategically linked to the standard, since it is currently the only one tackling the issue of seamless interfacing the digital domain (event-based) with the physical manufacturing domain (scan-cycle based). The IEC 61499 standard was defined in 2005 but as it is now 10 years old it has limits and needs to be updated. This has to be done coherently with the IEC and CEN standardisation bodies, while guaranteeing extensive feedback from the industrial stakeholders. The project approach is therefore based on 5 pillars, 3 of which address technology, with additional platform and ecosystem pillars. The developed technologies and platform will be demonstrated in showcases to increase acceptance by the market. The aim of these is to involve people and also to push for a new release of the IEC-61499 standard. In the ecosystem pillar a network of competence centres ("European Competence Network for IEC-61499", ECN-61499) is being created around Europe, involving both technology transfer stakeholders and industrially interested companies (part of a future Technology Group). The project is naturally compatible with both horizontal and vertical integration with other digital platforms for manufacturing, and is currently exploring such an opportunity through a collaboration with the FAR-EDGE project, which is developing a virtualised approach to factory automation.

Reference implementations (Sergio Gusmeroli, Politecnico di Milano)

The presentation gave an overview of a wide range of projects that can be considered to have produced, or are producing, reference implementations. It was noted that FIWARE had developed open specifications and then reference implementations had been built upon these. There are many activities looking at platform reference implementations and this includes RAMI, IIC, Industrial Data Space, and OpenIoT. There is also an increasing interest in federation of platforms within sectors to create reference implementations. The BEinCPPS project, for instance, aims to integrate CPS and IoT to provide a Cloud Service platform that will be demonstrated in 10 classes of applications involving local competence centres and manufacturing SMEs. The ultimate aim of this Innovation Action is to dramatically improve the adoption of CPS platforms all over Europe by creating regional innovation ecosystems, made of competence centres, manufacturing enterprises and SMEs. It is further planned in the MIDIH project to integrate together different platforms. This links with FITMAN which looked at the use of Internet technologies in manufacturing. Here the results were showcased in 10 use case trials (4 conducted by Large Enterprises, 6 by SMEs) that tested and assessed the suitability, openness and flexibility of FIWARE Generic Enablers. The use case trials belonged to several manufacturing sectors such as automotive, aeronautics, white goods, furniture, textile/clothing, LED lighting, plastic, construction, and manufacturing assets management. Finally, the OEDIPUS project which is being driven by EIT Digital is further developing enablers, e.g. data analytics that could be potentially provided as services in manufacturing.

Concluding Remarks

The Workshop was successful in bringing together experts from the manufacturing domain to discuss the use of platforms in Digital Manufacturing. It was noted that the Digitising European Industry initiative is driving the development and uptake of platforms; however, there is still some discussion on what a platform is as the concept means different things to different communities. With respect to manufacturing there is a clear need for an "operating system" type platform to connect together manufacturing systems both internally within organisations, and also externally outside of orgranisations. Here there is also a need for supporting business platforms to allow companies to collaboratively work together. A challenge is that the manufacturing domain is moving fast. There are needs for process optimisation, flexibility for customised production, and increasingly networks of SMEs are coming together dynamically to produce products. At the same time technology is changing at an exponential rate with many new innovations in Cloud computing, edge computing, blockchain, Digital Twin, etc., which are resulting in fundamental changes to the automation pyramid. There is a growing gap between the exponentially changing technology and implementation by organisations. Help is needed to allow industry to adopt new technologies and address this gap. In the meeting 4 main themes were emphasized:

- **Reference Implementations Demonstrating Interoperability** - Reference implementations are a good way of demonstrating the power of platform approaches to industry. Piloting is seen as very beneficial to gain acceptance for new technologies and also in supporting the development of standards. Connectivity and data will drive the future and to support this there is a need for platforms to develop open standards that support interoperability and data exchange.
- **Changing Mindsets and Creating Digitisation Skills** - The importance of the human within the manufacturing ecosystem was particularly emphasized. It is necessary to take this into consideration in collaborative manufacturing environments. There are different cultures, e.g. family owned businesses, and different levels of skills and competences. In order to change and adopt new ideas for digitisation the right mind set is required along with the necessary development of digital skills. This needs to be combined with education on security as the human at present tends to be the weak link within the system.
- **Growing an Ecosystem** - There is a need to grow a supporting ecosystem around digitisation. This can be achieved via provision of open source software, supporting toolkits and standardisation to make integration easier. A key challenge is to convince companies at a national and local level to engage in digitisation. Here the Digital Innovation Hubs have a crucial role to play in combination with incentives that encourage companies to digitise.
- **Sharing of Experience and Collaboration** - The meeting highlighted that there are many activities at the national and European levels that are contributing to digitisation. It was also notable that many developments had been made as a result of continued research and development building upon previous project outcomes. Looking to the future there is a need to share experiences and collaborate to avoid silos being created.

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Participants

Haydn Thompson	(Editor) THHINK
Gani Ademi	RKS-GOV
Jon Agirre Ibarbia	TECNALIA
Jon Arambarri	VIRTUALWAREGROUP
Olivier Armbruster	EXCELCAR
Aitor Arnaiz	TEKNIKER
Juanan Arrieta	IDEKO
Hideaki Asada	JMC
Christine Balch	TNO
Veronica Bandu	CONFINDUSTRIA
George Beers	WUR
Wernher Behrendt	Salzburg Research Forschungsgesellschaft
Monica Bellgran	KTH
Menouer Boubekeur	UTRC
Hamid Bouchachia	BOURNEMOUTH
Aurimas Brazys	FIPRA
Stuart Campbell	ICE
Franco Antonio Cavadini	SYNESIS-CONSORTIUM
Marcello Colledani	Politecnico di Milano
Angel Conde Manjon	IKERLAN
Myriam De Greef	QED
Silvia De La Maza	INNOVALIA
Chris Decubber	EFFRA
Paolo Dondo	MESAP
Isabelle Dussutour	ID4CAR
Ragnhild Eleftheriadis	SINTEF
Leire Etxeberria	MONDRAGON
Alzaga Etxeita	TEKNIKER
Antoine Feral	ROLLS-ROYCE
Berta Ferrer Llosa	ECSEL EUROPA
Marco Filippozzi	FBK CMM
Filip Geerts	CECIMO
Rositsa Georgieva	EUROPEAN COMMISSION
Konstantinos Georgoulias	LMS
Pasquet Gerard	ARCELORMITTAL
Jon Kepa Gerrikagoitia	IDEKO
Benjamin Goetz	IPA FRAUNHOFER
Haluk Gokmen	ARCELIK
Fabio Gregori	UNIVPM
Sergio Gusmeroli	Politecnico di Milano
Sam Helmer	TNO
Knut Hufeld	Infineon
Essi Huttu	DIMEC

Miguel Angel Iñigo	MONDRAGON
Hiroo Inoue	JMCEU
Mauro Isaja	ENG
Bjorn Jager	HIMOLDE
Jana Janson	REGION-STUTTGART
Kostas Kalaboukas	SINGULARLOGIC
Julia Kantorovitch	VTT
Pieter Kesteloot	SIRRIS
Dimitris Kiritsis	EPFL
Pierre-Jean Krauth	ARCELORMITTAL
Liliana Lai	
Oscar Lazaro	INNOVALIA
Ronan Le Goff	CT-IPC
Marta Ledke	LANXESS
Max Lemke	EUROPEAN COMMISSION
Weidong Li	COVENTRY
Sara Mateo	ZABALA
Gokan May	EPFL
Sylvie Mayrargue	CEA
Conor Mccarthy	UNIVERSITY OF LIMERICK
Danny Mcmahon	STRATH
Iulia Mihail	RESEARCH
Ronny Mingels	ARTTIC
Néjib Moalla	UNIV-LYON2
Solène Molard	OCCITANIE-EUROPE
Merete Nørby	MADE
Bulto Olivier	
Željko Pazin	EFFRA
Johan Peeters	Bosch-Rexroth
Kai Peters	VDMA
Denys Plakhotnik	MODULEWORKS
Jan Post	Philips
Antonis Ramfos	ATC-INTL
Martin Rastetter	DATEV
Polyvios Raxis	ATLANTIS ENGINEERING
Liceth Rebolledo	EURECAT
Patrick Reynen	NIMBIAN
Joao Rocha	EUROPEAN COMMISSION
Martin Ruskowski	DFKI
Xabier Sabalza	LORTEK
Cristina Sandoval	EUROPEAN COMMISSION
Jasmine Scavee	JMC
Arnd Schirrmann	AIRBUS
Julia Schmalenberg	FRAUNHOFER
Sebastian Scholze	ATB-BREMEN
Sebastian Schröck	DE
Enno Schumacher	AIRBUS
Ulrich Seldeslachts	LSEC
Francesca Siciliano In Stevens	ARCONIC
Egbert-Jan Sol	TNO
Ilaria Sticchi	FEDERAZIONE ANIE CONFINDUSTRIA
Sergio Tringali	CONFINDUSTRIA
Harry Tsahalis	PARAGON
Kitayoshi Tsumita	JMC
Reijo Tuokko	DIMEC

Fernando Valdés Verelst	MINECO
Edgaras Valius	
Filip Van Nieuwenhuyze	THYSSENKRUPP
Alex Van Nieuwland	TUE
Tim Vanderbeke	4XSCIENCE
Hans Vanderwegen	4XSCIENCE
Olli Ventä	VTT
Eva Verbias	MFA
Nemrude Verzano	SAP
Daniel Wentzlaff	SACHSEN-ANHALT
Arian Zwegers	EUROPEAN COMMISSION