Road2CPS – Workshop on Future Platforms

Are platforms a solution for our industrial competitiveness? How can they benefit from CPS, IoT and Big data?

Report Road2CPS Workshop,

8th October 2015 Torino, Italy

www.road2cps.eu

Disclaimer: The views expressed here are those of the workshop participants and do not necessarily represent the official view of Road2CPS on the subject.

Executive Summary

The Road2CPS Workshop on Future Platforms was held on the 8th October 2015 in Turin, Italy.
The main motivation of the workshop was to understand the current situation of European players in the field (ongoing platform activities) and analyse to which extent existing efforts are addressing needs and demands from different industrial sectors in an effective way. Road2CPS gathered 35 experts from industry, academia and policy making bodies with knowledge and experience in Open Platforms and Architectures, both horizontal (cross-sectorial) and vertical (domain-oriented) for this purpose.
They contributed to a lively discussion on platform concepts where some characteristics and challenges for future platforms were identified. Discussions were also useful to create awareness about the different European initiatives and stimulate the alignment and coordination between them.

The workshop was structured around the following pillars:

- understanding the offer (i.e. platforms resulting from projects funded by the European Commision (EC) or other bodies)
- understanding the demands and needs coming from different domains: manufacturing; automotive; energy; smart cities, etc.
- panel discussion and interactive sector-driven session (in groups), sharing outcomes; checking potential gaps from platforms vs. needs

More specifically, seven presentations from the supply side (a view on existing/developing platforms) were provided:

- Crystal (Christian El Salloum, AVL LIST GmbH)
- Arrowhead (Pär-Erik Martinsson, Lulea University)
- Virtual Fort Knox (Ursula Rauschecker, Fraunhofer-IPA)
- FITMAN (Sergio Gusmeroli, TXT)
- FIWARE (Nuria de Lama, Atos)
- Industrial Ring 4.0: A platform for the Catalan Smart Industry (Sergi Fuiguerola, i2CAT)
- HANA Platform (Raik Hartung, SAP)

The different presentations from the platforms providers revealed strong similarities in terms of technological conception and also economic success factors. The presentations indicated that there is a strong need for openness, interoperability/standardisation and flexibility, early user/customer involvement, as well as definition of the right business concept behind it. European Union (EU) funding can considerably help to realize a successful platform strategy in the EU by bringing the right stakeholders (sometimes also competitors) together; this should lead to agreements on standardised approaches and the setting up of successful ecosystems.

Regarding the demand side (a view on the sectorial requirements and needs), five presentations were provided:

- CPSoS (Christian Sonntag, Eutexoo)
- Manufacturing/Automotive (Óscar Lazaro, Innovalia)
- Energy (Alexander von Jagwitz, Baumgroup)
- Smart Cities (Lanfranco Marasso, Engineering)
- Manufacturing (FoF) Sergio Gusmeroli, Politecnico di Milano

Presentations focused on domain specific demands and needs but also identified a large number of common cross-domain topics. Even though some differences exist in terms of sectors (for example, while some domains are more open to changes others are reluctant to adopt new technologies), many of the necessary building blocks raised by the sectorial representatives were repeated.
The panel discussion as well as the interactive session focused mainly on the most pressing needs (technological solutions as well as requirements for a successful implementation) and actions to be taken. A short analysis comparing domain specific but also cross-domain demand and offering to identify the current gaps was conducted. It became clear that there are already promising solutions in place, of which some are being tested by customers already; nevertheless, further developments and maturity are urgently needed to fulfill industrial requirements in a production environment.

A need for a more coherent (unified) regulation has been pointed out by various domains, but care has to be taken not to hinder the development of new markets. Privacy is a key issue from domains collecting personal data (energy, transport, smart city). The market should drive standardisation especially to promote interoperability and avoid vendor lock-in. There is a need to engage with industry - specifically SMEs - as well as to build innovation ecosystems around the stakeholders. Initiatives like I4MS are appreciated as starting point and should be continued or even enhanced. An ecosystem of users needs to be developed in order to sustain new platforms, which basically means that we should not only work on the supply side (developing new platforms and frameworks) but should work to create the demand.

From all presentations and activities during the day it became clear that there is a need for key actors in Europe to come together as the only way to face the strong competition coming from US platforms that currently dominate the market. EU-funding as well as industry commitment can massively help to generate the right standards and interfaces. Moreover, EU-projects are a good way to bring the relevant stakeholders together, enter into dialogue and create the innovation ecosystem for a sustainable value proposition.

NOTE:
All presentations are available on the Road2CPS website under 'resources': www.road2cps.eu

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Introduction

One of the factors leading Europe to focus innovation is the fact that Internet has transformed many industries. A few representative examples of this are the music or the tourism industries, but many other examples also exist. Consider, for example, recruitment processes in companies (very much supported by social networks) or simple actions we all do in our daily life, like taking a taxi (many people do this through Uber or other apps installed in their mobile phones) or calling someone (where we have replaced to some extent traditional voice calls by IP-based applications such as Skype or WhatsApp). The last example has had an enormous impact on the incomes of Telecom Operators; as a result, many of them are now transforming some of their operations to become Internet companies and avoid being considered as pure commodity providers. **Internet technologies are not a threat in itsel**f. The threat is that US giants such as Amazon, Google, Skype and many others are precisely the ones that have the best position in this playground. **The EU has been traditionally a very powerful player in industrial environments/platforms and not on consumer markets; and still is. But…Will this last forever?**

Concepts such as Industry 4.0 reveal that also industrial domains like manufacturing are entering a new phase, which will be characterized by internet-related technologies, such as cloud computing or Internet of Things. **Business models will evolve** as a consequence of that, **and probably also the players that will be involved in the different value chains.** For example, consider car manufacturing, which is a very relevant industry for Europe. Manufacturers are investing in the autonomous car, which happens to be a data-intensive business, where a lot of ICT is involved. What does it mean exactly? We predict that future competitors of companies such as Volkswagen, Volvo, Renault or Fiat (to name a few) will be technology companies such as Apple or Google, rather than other car manufacturers. This is an example of the way a value chain can change, and Europe cannot wait to react to such changes. Therefore, **adapting to this new technology landscape is a must, acknowledging the threats but also the opportunities.**

The purpose of the workshop organized by the Road2CPS project was precisely creating awareness about this situation and promoting the dialogue between organizations that could collaborate in concrete actions towards a more competitive EU industry understanding platforms as a tool that could facilitate and accelerate this innovation process.

This reeport provides an analysis of the discussions at the Workshop on Future Platforms organized by the Road2CPS project. It summarizes some of the major challenges Europe has to face if a real successful strategy on platforms is to be established. Moreover, the outcomes of the Workshop on "Platforms for connected Factories of the Future" held by the EC in Brussels on the 5-6 October[1] are summarized and discussed in comparison to the Road2CPS workshop conclusions within the last chapter.

[1] The information provided here summarizes some of the statements included in the draft report of such workshop, as circulated by the European Commission.

Agenda and Scope of the Road2CPS Workshop

The workshop was held according to the following agenda:

	Road2CPS – Workshop on Future Platforms
09:00	**Welcome and Introduction** ▪ *Road2CPS mission (Meike Reimann, Coordinator Road2CPS, Steinbeis-Europa-Zentrum)* ▪ *Setting up the context for the workshop: methodology (Nuria de Lama, Atos)*
9:10	**European Commissions View** ▪ *Towards platforms for Digitising Industry (Werner Steinhoegl, European Commission)*
9:40	**Panel 1: Platforms: the supply side (a view on existing EU Platforms)** ▪ *Crystal (Christian El Salloum, AVL LIST GmbH)* ▪ *Arrowhead (Pär-Erik Martinsson, Lulea University)* ▪ *Virtual Fort Knox (Ursula Rauschecker, Fraunhofer-IPA)* ▪ *FITMAN (Sergio Gusmeroli, TXT)* ▪ *FIWARE (Nuria de Lama, Atos)* ▪ *Industrial Ring 4.0: A platform for the Catalan Smart Industry (Sergi Fuiguerola, i2CAT)*
11:00	*Coffee Break*
11:30	**Panel 2: Platforms: the demand side (a view on the sectorial requirements and needs)** *Manufacturing, Health, Transport, Smart Cities domain demands* ▪ *Raik Hartung, SAP* ▪ *Christian Sonntag, Eutexoo* ▪ *Óscar Lazaro, Innovalia* ▪ *Alexander von Jagwitz, Baumgroup* ▪ *Lanfranco Marasso, Engineering* ▪ *Sergio Gusmeroli, Politecnico di Milano*
12:30	*Lunch*
13:30	**Interactive Session including Panel Discussion** *With all speakers on success factors, needs, threats, aligning supply and demand, recommendations, next steps...& more* *To align the offering of platforms and building blocks and with requirements and needs in the specific domains, identify gaps and draw conclusions*
14:50	**Conclusions and next steps**
15:00	*Close of the Workshop*

The main objectives of the workshop are summarized as follows:

- Discussions on platform concepts: How should Europe invest in platforms? Why could this be beneficial to CPS and European industries? Importance of cooperation, reference architectures, standards and testbeds? Learn from ongoing and "Gold" examples shared with the audience.
- Alignment of the work of different European initiatives to ensure coherence of results (for example, big data seems a "hot" topic in many CPS-intensive sectors and this should be worked out in cooperation with the recently launched Big Data Value PPP).
- Matching supply and demand. Where do you see opportunities for new platforms? Are current solutions fulfilling the needs of customers/users? What is the way forward to promote the right innovation ecosystems? Comparison of vertical platforms and horizontal ones? Relevance of open standards? What should be the approach towards Open Source solutions?
- Constituency building: join communities to define coherent future solutions for interoperable platforms in different contexts and domains.

European Commission view

Towards platforms for Digitising Industry / Werner Steinhögl DG Connect - A3

Werner Steinhögl from the European Commission introduced the EC's view on platforms, highlighting the fact that platforms should not only be perceived in a technological way but also as a basis for business and economic growth. Important points within the presentation (see also presentation on Road2CPS website) were:

- Real-time systems and safety-critical systems are the key nodes of the digital value chain. There is a significant competitive advantage to those who can master these challenges
- In the context of this conference Werner acknowledges that the ARTEMIS community already works on key nodes of the value chain of the future: safety-critical and real-time systems. The control of these key nodes provides a competitive advantage and Europe needs to be prepared
- A process of digital transformation is currently ongoing in many domains, particularly in manufacturing, which is becoming increasingly automated. More automation leads to increased efficiency with regards to resources such as electricity, and increased precision in regards to products.
- Digitilisation offers many opportunities to deliver different products in more effective ways, including process transformations (from logistics and product design to automation). This trend also impacts business models, by blurring boundaries (between products and services), and reshuffling value chains. We expect to see a strong emphasis on added value services, built on e.g. real-time information data analytics, etc., with a shift towards XaaS (everything as a service). For example, aircraft manufacturers to deliver performance rather than an engine.

However,

- Currently there is a lack of standards and interoperable solutions (these may be currently technically feasible but at a high cost and without relying on cost-saving standards)
- We see the advent of a new competition coming from non-EU digital platform owners (e.g. Google), while we note a fragmentation of effort in Europe

Key action lines pushed forward by the EC include:

- Digitizing industry initiatives (15% of GDP €2,250 B): this includes creation of digital innovation hubs, developing smart regulations for industry, adapting and retraining workforces, investing in platform leadership; and building a strong digital sector: key programmes include 5G, ECSEL, IoT, Cyber security, photonics, robotics, big data (€900 B) (see yin/yang slide)

Platforms

There are many platforms available to aid developers and innovators as they develop new products and services, including approaches for reference architectures.

- A "platform" includes technologies and standards and *also* business models. Successful platforms provide a means to bring a community together, connecting elements of a marketplace. Examples include:
  - Amazon marketplace – connects people selling items with people who want to buy (people who search - advertisers)
  - Android/Apple – connects people with smartphones looking for functionality, with developers/sellers of apps delivering that functionality (people who buy phones - developers of apps)
  - Google – connects people searching for things with advertisers looking for targeted groups of people (people who search a product - companies selling a product)
- There is in general not one common platform for CPS, probably there is need for several.
- Consensus building to agree upon platforms is important.
- Platforms are to be considered not only as stakeholder groups (Industrie 4.0, ETPs, etc.), or technological platforms (middleware, reference architectures, etc.) instead what is at stake are economical multi-sided market platforms creating value by enabling interactions between two or more groups (e.g. suppliers, customers, intermediaries)

Platform Presentations

Crystal / Christian El Salloum AVL

CRYSTAL[2] (CRitical sYSTem engineering AcceLeration) takes up the challenge to establish and push forward an Interoperability Specification (IOS) and a Reference Technology Platform (RTP) as a European standard for safety-critical systems. This standard will allow loosely coupled tools to share and interlink their data based on standardized and open Web technologies that enables common interoperability among various life cycle domains. CRYSTAL is driven by real-world industrial use cases from the automotive, aerospace, rail and health sector and builds on the results of successful predecessor projects like CEASAR, SAFE, iFEST, MBAT on European and national level.

- There's enormous complexity in developing an engineered system – one product may involve up to 1000 engineering support tools. There's significant manual effort involved in "integrating" data from these tools or porting information between them. This makes production and other engineering activities inefficient and less effective than they could be. This is the context of Crystal, which focuses on critical systems, with the aim of facing the growing tool landscape where users pick several tools for their needs but suffer from the lack of interoperability.
- Options for performing integration between tool outputs include nowadays:
  - Point-to-point data integration – taking data directly from one tool for import into another, taking into account each tool's own unique specifications. This activity is very difficult to scale up to a real-world project, with large numbers of tools
  - Vendor-provided integration – buying products from one (or a small number of) vendor(s), and relying on the tools they produce to handle integration and porting of data from one tool or process to another in a proprietary way. The key problem is that this approach results in vendor lock-in, and risks associated with future withdrawal of tool support, loss of important tool functionality, or disappearance of the vendor from the marketplace, and an inability to exercise choice between tools.
  - The approach proposed by Crystal. Crystal has developed an open integration platform which rests on an underlying landscape of varying tools. It is based on principles which have been demonstrated to be successful in other contexts, particularly principles of linked data as defined by the W3C
- The road to developing a successful platform includes:
  - Base the platform on sound, well-demonstrated principles
  - Build a critical mass of support – including a user base. Crystal has achieved this partly as a result of support from the ARTEMIS- IA
  - Retain a philosophy of openness. Crystal has supported the creation of an eco-system that creates and governs open standards
  - Facilitate uptake by new stakeholders.

[2] http://www.crystal-artemis.eu/

- The Crystal consortium includes tool users (which are engineering companies) and tool developers
- End-users are large OEMs e.g. Daimler, Airbus
- Plans for standardization through the OSLC (group committed to developing standards that enable software lifecycle tools to share data within the OASIS open standards consortium"[3]).
- Maintenance of the platform after the project duration (including developing a sustainability plan)

Arrowhead / Pär-Erik Martinsson, Lulea University

Arrowhead[4] targets five business domains: Production (process and manufacturing), Smart Buildings and infrastructures, Electro mobility, Energy production and Virtual Markets of Energy. In these domains there are a number of technological architectures used for implementing SOA solutions. One of the grand challenges of Arrowhead is to enable interoperability between systems that are natively based on different technologies.

- Arrowhead is about SoSs built on IoT
- The Arrowhead framework for industrial automation promotes a distributed and networked architecture instead of relying on conventional centralized architecture e.g. SCADA
- Pär-Erik underlines the fact that platforms are indeed an "innovation process" which starts from technologies and a business concept, and value propositions (which may either be a revenue or free based) to customers
- The business model Arrowhead assumes is as follows:
  - The **Platform** feeds into **Business Concept,** and also into **Technology**
  - **Technology** and **Business concept feed** in to a **Techno-Economical Paradigm**
  - This produces a **Value Proposition**
  - The **Value Proposition** feeds into **Revenue**, and **Revenue** feeds back into the **Value Proposition**
- A variety of revenue streams and value propositions are possible when commercialising platforms; in some cases the revenue may not come from a direct fee for using the platform.
- The interest of platforms lays precisely in their capacity to provide: scalability, different value propositions/business models (paying and non paying ones), etc.
- Examples that illustrate such different capacities are Google (which provides software, advertisement, and access to (non-paying) consumers); or Apple (which offers a focus on user experience/usability).
- Arrowhead is on its way to define different value propositions based on the project use cases
- Technology push is important because demand-pull may not be sufficient (when asked, people want faster horses…)

[3] http://www.oasis-oslc.org/node/7

[4] http://www.arrowhead.eu/

- Key message: we have to work harder at pushing new technologies and new products

Questions during the presentation

- **What are the differences between Arrowhead and Crystal?** They are similar in principle, but Arrowhead addresses the needs of different sectors. Arrowhead concentrates on process control in manufacturing, which has specific requirements regarding (for example) representation and handling of real-time information and timestamps etc., which are not usually needed by Crystal users.
- **What are your comments regarding standardisation and data interoperability**? Opinions are divided on the use of standardisation to tackle the problem of data interoperability – some support a process of standardising the data and processes for sharing data between tools; others prefer to maintain flexibility for different tools and sectors
- **How do you recommend tackling the problem of process control in manufacturing and increased reliance on the cloud?** We concentrate on the development of a local cloud, which is under local control. This gives the owner control over problems such as latency and security. We don't use cloud services over the internet for process control. However, of course manufacturers are naturally very cautious about adoption of cloud technology – it raises a lot of challenges for manufacturers and process industries.

Virtual Fort Knox / Ursula Rauschecker, FhG IPA

Virtual Fort Knox[5] is a platform that offers tailor-made functional IT solutions to manufacturing enterprises. This platform simplifies the use of information technology in value-adding processes and optimizes networking beyond geographical and company limits. Virtual Fort Knox builds on top of the concepts of Service-orientated architecture (SOA), Cloud orientation, task-oriented decomposition of IT systems, automated integration and community features.

- Virtual Fort Knox is a secure, federated platform for service-oriented apps, with support from innovative SMEs. It is funded by a German regional government programme and makes strong emphasis on service-oriented, modular framework. New apps can be added to the framework, formed by composing services. The platform is an example of a shift from product creation to producing value within an ecosystem.
- The model of the business context assumed by VFK can be summarised as follows:
    - At one level, VFK focuses on the development of a product (e.g., car). This process is vendor-driven
    - At the next level, it focuses on the delivery of services (e.g., autonomous driving). This process is customer-driven. There is a need to ensure that there is interoperability to support the development of services from the products that are available

[5] https://www.virtualfortknox.de/en.html

  - At the level above, VFK focuses on the delivery of a solution (e.g., mobility services). This process is "oligarch"-driven and results in/relies on a digitised community to be centred on the solution. There is a need for service-integration, to support the creation of solutions from the services which are available.
- Stakeholders involved in VFK include equipment manufacturers, software vendors and end users. More than 20 software providers are currently using the platform to develop and publish their services. Virtual Fort Knox: the "manufacturing service bus" is the core element, providing various services needed for the manufacturing processes (such as scheduling). It also includes a system of service subscription; 20 software vendors; 10 R&D funded projects and commits to have a commercial version available in 2016. Some cooperation requests have already been received from SMEs and Asia. As part of the ecosystem that has been established, FhG is founding a small company to commercialize the framework, with a focus on selling hosting and IT services to be able to use the platform.

Questions during the presentation

- **What's the business model of the new commercial platform?** Hosting the platform is the main focus of the business model from our point of view. For software providers, the business model is the use of the platform to sell their services.

FIWARE / Nuria de Lama, Atos

The FIWARE[6] platform provides a rather simple yet powerful set of APIs (Application Programming Interfaces) that ease the development of Smart Applications in multiple vertical sectors. The specifications of these APIs are public and royalty-free. In addition, an open open source reference implementation of each of the FIWARE components is publicly available so that multiple FIWARE providers can emerge faster in the market with a low-cost proposition. FIWARE Lab is a non-commercial sandbox environment where innovation and experimentation based on FIWARE technologies take place. Entrepreneurs and individuals can test the technology as well as their applications on FIWARE Lab, exploiting Open Data published by cities and other organizations. FIWARE Lab is deployed over a geographically distributed network of federated nodes leveraging on a wide range of experimental infrastructures.

- Companies in different sectors (e.g., energy, transport, etc.) are investing in the same technologies to solve similar problems. This includes major functionalities such as cloud services, big data analysis, context awareness, and IoT support. FIWARE was conceived as a way to share the investment by identifying needs and requirements from different sectors and set up the common building blocks that could satisfy those generic functionalities.
- The idea was then to provide components but let users build their own applications out of them

[6] https://www.fiware.org/

- FIWARE delivers a range of "functional blocks" which provide services in the aforementioned areas (with a special focus on cloud computing capabilities, context awareness, IoT and big data analysis).
- In the beginning, the major focus was on building the technology, including the APIs. However, after deploying and testing the technology FIWARE understood that the focus should also be on providing access to data and creating an ecosystem.
- The FIWARE platform is one part of the overall process:
    - There is a range of support activities, training etc. offered, and these are important to facilitate creation of new users
    - Technology without a supporting ecosystem has no value
- Going in deeper detail, FIWARE is an open standard cloud-based platform based on Openstack + rich library of generic enablers. It includes the so-called FIWARE catalogue: API to deploy cloud services; easy plug&play for IoT; security monitoring
- The major goal is to support manufacturers and designers and reduce the time to market for their products and services
- Major functionalities delivered by FIWARE include:
    - Web UI
    - Security
    - I2ND apps etc.
- The functional blocks provided by FIWARE are all interoperable
- Platforms must be open and evolvable. FIWARE has been in development for some years, and we've noticed that the needs of the users have changed along this period. So we have adapted to new requirements and as a result of this, some functionalities have been removed from the platform while new ones have been added. This kind of evolvability is important if a platform is to succeed.
- Specifications for FIWARE are all open, avoiding vendor lock-in. It's easy to change providers with FIWARE – e.g., if one provider is no longer suitable, it's easy to switch to another provider. This is important in almost every sector, but it is becoming to be a true competitive advantage in those environments where budgets are limited, such as smart cities.
- FIWARE Lab is the central piece of the eocystem. Users can register on the site and start using and testing the platform – the site acts as a "meeting point" between the different stakeholders (data providers, application sponsors, FIWARE providers and startups and developers).
- Many platforms developed with EU grants have come up with interesting technical results; however, they have not been successfully commercialised. A plan for commercialisation is very important and should be taken into account early on in the lifetime of a platform as a major goal
- Achieving a critical mass of support is very important. FIWARE has an acceleration programme for new entrants/SMEs – to persuade SMEs and innovators to try out the technology for free – helps to create demand. Note that this type of programme is not always suitable for every sector, however.

- As part of the strategy to promote FIWARE as de-facto standard for Smart Cities, an initiative was born in the beginning of 2015. Its name is OASC[7] and stands for Open and Agile Smart Cities initiative. The initiative has made possible the commitment of more than 100 cities to follow specific principles that promote the interoperability between solutions, thus contributing to the realization of the European Digital Single Market.
- From a commercial point of view, additional achievements are the commercial alliance created between Telefónica, Atos, Orange and Engineering to provide FIWARE-based services for Smart Cities. This alliance was presented in the last edition of the Mobile World Congress in Barcelona, followed a few months later by the launch of OASC in CeBIT 2015. Operational FIWARE nodes are already in place for those interested in using FIWARE in a production environment.

Questions during the presentation

- **How do you support sustainability?**
  - The platform is open, which ensures an ecosystem where all stakeholders can build win-win relationships. It enables startups, SMEs and big companies to develop their products and services based on Future Internet capabilities. They can use the functionalities as a service or download open source software and install it on their premises if they want to run their own infrastructure
  - Furthermore FIWARE provide the tools for those that want to set up their own commercial FIWARE node (the so called FIWARE-Ops), enlarging the network of providers and thus the resources at worldwide level.
- H**ow to convince people to use FIWARE technologies?**
  - A lot of information is available online, but FIWARE provides additional tools such as large set of YouTube introductory videos, e-learning platform (FIWARE Academy) and a great number of face-to-face technical trainings held in many EU countries. In addition, it has set up a network of incubators that provide FIWARE support at local level (this is of particular relevance to scale)
- The FIWARE platform was seen as a good example other platforms could learn from

[7] http://www.oascities.org/open-and-agile-smart-cities/

FITMAN / Sergio Gusmeroli TXT, POLIMI

The mission of FITMAN[8] (Future Internet Technologies for MANufacturing industries) is to provide 10 industry-led use case trials in the domains of Smart, Digital and Virtual Factories of the Future on top of the FIWARE platform. FITMAN Trials (4 conducted by Large Enterprises, 6 by SMEs) will test and assess the suitability, openness and flexibility of FIWARE Generic Enablers while contributing to the STEEP (social-technological-economical-environmental-political) sustainability of EU Manufacturing Industries. The use case trials belong to several manufacturing sectors such as automotive, aeronautics, white goods, furniture, textile/clothing, LED lighting, plastic, construction, and manufacturing assets management. It is therefore an excellent case to understand the potential opportunities of using an open platform in the specific context of manufacturing.

- FITMAN is a platform which takes FIWARE and adapts it to provide generic services to the manufacturing industry. FITMAN takes data from the shop floor and makes it available to systems engineers.
- Manufacturing is key for the EU economy, and is currently undergoing a significant digitisation process. In some ways manufacturing can be a conservative industry so this is a big paradigm shift.
- Manufacturing has started with a lifecycle which sees roughly similar amounts spent on: initial R&D; on production; and in aftersales and services. Over time this has moved increasingly to a lifecycle where costs of production have fallen, and costs associated with the initial R&D (pre-production) and later post-sales services (post-production) have increased.
- A key message: there is not enough focus on automation to support the manufacturing process as it moves into a stronger focus on services
- FITMAN has produced three platforms built on top of FIWARE:
    - Smart factory, which deals with the optimization of the production processes (in terms of production cost reduction, efficient energy usage, improvement in production reliability, production machines usage, etc.) via the monitoring and management of the production process and of its components.
    - Digital factory, which concentrates on providing services for engineers – how to cope with post-production life, recycling, end of life etc.
    - Virtual factory, with a focus on supporting supply chain management
- There are Reference Architectures (RAs) for each of the key enablers, which can be fitted together into an overarching FITMAN reference architecture
- There are 10 businesses (large scale and SMEs) which have trialled FITMAN. Future pilots to be funded under FoF
- A new project, BEinCPPS, is working on the inclusion of Crystal results to FITMAN
- FITMAN is not ready for automation yet, as it is more a set of services around the factory, but with the inclusion of Crystal a more mature approach would be possible. An initial step has been made, but further investment would be required to realize this vision.

[8] http://www.fitman-fi.eu/

Questions during the presentation

- The EC pointed out that FITMAN presents a good example of CPS engineering – the FIWARE providing the *cyber* elements, applied to *physical* processes in manufacturing.
- **What are the plans for commercialisation?** FITMAN is not quite planning to commercialise immediately but aims for this in the long-term. Options could include providing consultancy, or creating an open platform

Industrial Ring 4.0 - a platform for the Catalan smart industry / Sergi Figuerola

The Industry Ring initiative (Anella Industrial)[9] is a project with an objective to deploy sharpshooting telecommunications infrastructure to connect enterprise sectors and resources at high technological level. The project aims to increase the competitiveness of the Catalan industrial sectors, harness collaborative work in "R+D+i" and to ensure that industrial companies and sectors have real access to high quality ICT infrastructures. The initiative is using the automotive sector as a pilot.

- There is an enormous competitive potential coming from ICT applied to industry. This is supported by the importance of ICT in manufacturing in various government strategies worldwide. For example, the US has a government strategy on how to achieve "SmartAmerica", whilst the German government has published its strategies for "Industrie 4.0".
- Industrial Ring is part of the "Four Motors for Europe" project. This is a collection of four regions around Europe which are dedicated to create new "smart regions". Smart manufacturing will be one key focus within this project, supported via the SmartCat initiative based in Catalonia, and the industrial and ICT sectors of Catalonia.
- We want to work with already existing platforms, including FIWARE, FITMAN, Virtual Fort Knox, etc with two major focus areas:
  - operational services are services which already exist – e.g., providing functionality (e.g. services for telecoms)
  - experimental services built on top of the existing infrastructure
- Industrial Ring users are association members. The initiative is very much user-driven:
  - Co-designed with users
  - Based on internet technologies, particularly IoT
  - Aligns AI4.0 with the EU
- The goal for the platform is to become a world-class innovation club easily accessible from every region. The first community of users already established is the automotive industry; second is bioinformatics. Based on initial steps we could say that the needs are quite basic for first users, or said in a different way, the offering is somewhat too advanced for the demand side.

[9] http://www.anellaindustrial.cat/en

SAP / Raik Hartung

SAP HANA[10] is an in-memory platform that combines an ACID-compliant database with advanced data processing, application services, and flexible data integration services. It removes the burden of maintaining separated legacy systems and siloed data. In terms of capabilities, the main offering of HANA can be summarized as follows: database Services, Analytics & Data Processing, Application Development & Deployment, Data Access, Integration & Quality, as well as support for Administration & IT Operations.

- Key challenges in most domains are security, scalability and interoperability.
- SAP offers a cloud platform – HANA. Running on the cloud, it allows businesses to scale up their data operations and the number of connections. We can connect devices to HANA, and HANA collects data from sensors and devices and collects it in a "virtual cockpit", where it can be analysed.
- Through a live demo performed during the workshop, attendees could see the way HANA enables the registration of any kind of device and shares the data coming from the sensors of the device (the semantics of the data are provided by the device and not known from the platform). All inputs are treated as pure data, meaning that HANA is providing a platform for connecting and gathering data, whilst application logic and intelligent processing that understands what the data represents can be added on top.
- Data diversity is a challenge in this field – we need a way to connect different types of devices
- One of the priorities should be to spend time and effort making data structured for easy interpretation and exchange.

[10] http://hana.sap.com/abouthana.html

Demand Presentations

CPSoS / Christian Sonntag TU Dortmund

- CPSoS is an EU-FP7 CSA concentrating on roadmapping and the needs of cyber-physical systems of systems (SoS). These are systems which exhibit features of SoSs and CPSs.
  - CPSs have tight integration
  - SoSs have dynamic behaviour, emergent functionality, are continually evolving and have autonomous components
  - CPSoSs exist at the intersection of CPSs and SoSs. They have many interacting components and physical components as well as computational
- Many challenges are similar for CPSoSs across domains. CPSoS project concentrates on:
  - Transport
  - Physically-connected manufacturing and processing
  - Logistics
  - Smart grids
- Modelling is key in this domain, particularly for processing and manufacturing. There's a need for tools and platforms that support modelling techniques, particularly for:
  - Faster model development
  - Increasing model reuse
  - Meta modelling
  - Etc.
- There's a need for semantic systems integration which is
  - Highly dynamic, interconnected and flexible
  - Distributed
  - Can be quickly adapted to customer demands
- Platforms are needed for seamless integration of data and systems
- Platforms should support continuous evolution, development of and deployment of continuous systems (e.g., processing and manufacturing) that are and remain live during the development & deployment. Required platforms should allow industry to build on and cope with a heterogeneous infrastructure.

Questions during the presentation

- **How far have existing platforms met these industry needs? Are tools and platforms currently available which can meet these demands?** CPSoS has concentrated on studying industry needs, not current platforms. Looking at all the platforms available in academic communities, not all of them are ready for industrial deployment yet - there's a delay between developing a platform and being able to collect industrial feedback on its use. There are some platforms which may be available to meet some of these needs – particularly in integration – but our industrial partners don't feel that meet all of their needs are met by currently-available industry-ready platforms

- **How to cope with evolving live systems? How to deliver e.g., fault-free systems? I assume that it's necessary to use techniques such as isolating a fault within a system?** Modelling techniques are necessary to address fault tolerance in systems, and techniques such as fault isolation and fault recovery are needed, yes. This is still an area of study.

Domain needs in manufacturing / Oscar Lazaro Innovalia

- Innovalia delivers quality control equipment and services for manufacturers. The top strategic objective for 66% of manufacturers in our industry is to achieve consistent product quality.
- There have been several evolutions in the way in which monitoring of industrial processes is carried out. In the early days we started with monitors at some distance from the shop floor. Then we began creating and installing machines in a distant corner of the factory. Then we began to design and install machines directly on the production line. Now we are moving towards conducting monitoring via the cloud, as a way of coping with the scale of the data being handled during industrial design processes.
- To use the cloud for manufacturing processes, we need to have a highly modular architecture. The traditional monolithic systems we have been building is not suitable for applications deployed over the cloud.

Key Lessons

1. Size matters! Manufacturers generate huge quantities of data. Some examples and some comparisons:
    - 1 car production line has 500 providers, 2700 components.
    - One production line results in 30 Petabytes of data generated during design and building and production *every year*
    - Using 3D quality control, one car model being designed and produced will produce 400 Pb over its lifetime, *per factory*.

    Lifetimes are long – it's around 12 years to design, prototype, produce, and take out of service one model of car. This is why manufacturers are very reluctant to make significant changes to production lines mid-lifetime – they have made significant investments in creating the line. NB – these figures exclude e.g., test results and monitoring data. Comparisons:
    - Facebook generates 300Pb of data per year;
    - Amazon database is 900Pb;
    - Google Maps is 20 Pb in total.
2. There's a requirement for real-time transparency. We need structural transformation. We are looking at the whole supply chain ("broad eco-system") with diverse supplier presence. There's a strong need for increased new synergies with metrology, IT and automation and vendors. "Real time transparency" refers to traceability and visibility of the current state of the whole supply chain, which is typically spread across the globe.

3. Interoperability. Many regulations apply in this sector, including national, EU and global standards (e.g., produced by ISO). There's a need for standardisation on interoperability and data sharing. Requirements in this sector include tools which have:
    - high connectivity across stakeholders
    - speed
    - real-time transparency
    - reduced complexity
    - data-driven

- We need formalisms and tools for communicating.

Questions during the presentation

- **Are manufacturers able to pay for tools that deal with this scale?** Manufacturers look at it as a serious issue at the moment, because they already have to cope with storing this quantity of data. It's expensive to generate this data, there's a strong reluctancy to discard it. So there is pressure to move to a cloud-based solution.
- **How to deal with security issues when moving to a cloud-based solution?** Security is definitely an issue. One solution is to use internal clouds, which are under the manufacturer's control. There's a need for tools to interact at new levels to address this.

Smart energy platforms/ Alexander von Jagwitz, Baumgroup

- A key problem for the energy sector is that the industry will have to provide increasing amounts of energy whilst maintaining high service levels (e.g., no power outages, stable network etc.), and at the same time learning how to cope with the new energy landscape, which is very different to the energy environment of the past. Previously, the energy industry had a few large-scale producers and many consumers. This is being replaced with large numbers of small-scale producers and "pro-sumers" (sometimes acting as net producers, sometimes acting as consumers), and renewable sources which are a lot less controllable than fossil-fuel sources of energy. The sector needs to take a fossil-fuel marketplace and restructure it to a sustainable energy market place. This is a big paradigm shift for the industry, which has not altered its business paradigm significantly for many decades and tends to have a cautious approach to change.
- There's a need to manage consumption and demand in the new energy market, because renewable energy is less controllable. This translates into a need to create incentives for businesses and consumers to consume energy at periods which fit with energy availability when possible.
- There are many new service providers, operating in roles which did not exist until recently. These services are not provided by the utilities, but by innovative SMEs. A new utility ecosystem is developing, and is needed. The new model of utility that is emerging is closer to customers (service-based utility 4.0).

- Existing platforms focus on trading energy and flexibility (demand side and distributed generation management), smart homes.
- Commercial platforms do exist to support the energy sector – these are commercial and not EU-funded. They include:
  - Beegy
  - Next Kraftwerke
  - Entlios
  - Enernoc
  - Qivicon
  - Omnetric
- Some relevant EU initiatives here include
  - Finesce project
  - FEN (Flexible Elektrische Netze) – a commercial consortium
- Open interfaces are important
- Protocol and data modelling interfaces need to be defined for the energy sector
- Security considerations are a significant driver for the sector. There's awareness that decentralised grids are needed, which can be more resilient to attacks. A key priority for the industry in terms of resilience is to be able to recover quickly from an attack, and resume services as quickly as possible (book recommendation Marc Elsberg "black out").

Smart Cities / Lanfranco Marasso, Engineering

- Key idea of smart cities is to transform cities into a digital platform that enables economic growth and citizen well-being – it's not just about delivering increased efficiency in municipal services
- Important initiatives and consortia include:
  - Alliance for the Internet of Things (AIoT) co-chairing the theme on Smart Cities
  - Big Data Value Association (BDVA)
  - Open and Agile Smart Cities (OASC) Initiative
  - FIWARE – used for smart cities
- Key technologies include:
  - IoT
  - Standardisations
  - Big Data
  - Cloud
- Smart Cities require less focus on technology, and more focus on operations and benefits. In order to be sustainable, we need to get two aspects of smart cities in place: both ICT platforms *and* digital ecosystems. And for this, the right standards should be put in place.

Questions during the presentation

- **What is the driving force for standardisation?** I4MS is influential, an association for manufacturing SMEs. OASC is looking at common APIs. There's a need for accelerator programmes and service-ready solutions.

Manufacturing sector, Scorpius / Sergio Gusmeroli

- The major focus for the manufacturing sector at the moment is bringing together two aspects:
  - ICT offerings
  - Manufacturer demands (operational technology, FoF etc.)
- We need to be looking at increasing the Technology Readiness Levels (TRLs) of existing platforms and technologies. We should also be aware that TRLs may not be equally valid in all sectors – a platform that is rated with a high TRL in one sector may not be considered at a high TRL in another – it will depend on sector needs. We need to start looking at the *Market* Readiness Level (MRL), not the *Technology* Readiness Level. Is manufacturing ready to adopt this? And how do we measure readiness level to adopt this approach)
- Methodologies are needed for migrating to the new technologies and platforms
- There is a need for innovative business models and promote extensive education
- Significant training efforts are needed in order to upskill existing workforce to work increasingly with ICT tools, and to attract new talent in the manufacturing sector

Panel

All speakers were part of a panel and the complete audience was involved in the discussion. Discussions focused around the following themes:

COMPARISON OF PLATFORMS

- We can see many overlaps in the available platform offering: 1) data modelling; 2) shared components; interfaces/interconnection of platforms (of various domains). Data exchange seems to be a key point for interconnection of platforms. More pilots are still needed for energy with open data
- Crystal brought different engineering domains together, but now the problem is to feed results from data analytics back to the production line. Another point is: when the product is on the market, there will be constant updates, as we can see nowadays for the mobile phone sector. This will need to be addressed.
- Bringing actors together is a big challenge. EU funding to can really benefit here
- Much information has already been elaborated in EU projects and we should now focus on deploying and experimenting capitalizing existing outcomes and results.

NEEDS AND REQUIREMENTS

- What is needed technology-wise is there, the problem is essentially related to data sharing – for example, how to share the process of the different teams involved in the product life cycle. Right now the knowledge is not shared.
- We need to consider the very long lifecycles that most manufacturing industries are dealing with and the very complex nature of many CPS products – e.g., cars –together with the need of bringing closer different activities such as design, production, services, etc. Connecting different process in a system can result in the ability to create new disciplines that have not been considered before, and thus the ability to innovate.
- After recognizing that there is a need for connecting platforms and systems, another important requirement was pointed out: the increasing need of reaching and testing scalability. The EC could play an important role by supporting the deployment of large-scale pilots and demosntrators.

INDUSTRY NEEDS / SMEs

Questions:

- Are the needs of SMEs and large industry different? Can they come together?
- What are the needs of industries other than manufacturing?
- Do we need more technical data?
- How to persuade manufacturers to change production lines that already work “fine”?

Manufacturing related

- We need to overcome the mind-set of entrepreneurs who think that their process is already perfect. Perhaps the I4MS initiative is a way to help SMEs to try and experiment with those new technologies, by creating evidence and becoming an example for others. I4.0 has good business cases for large industry. Pilot studies should create the ecosystems for SMEs, with different offerings/track for implementation, different business cases.
- How to deal with the scale of the business companies? SMEs have different needs, and thus different platforms are needed. There are some good examples in FITMAN.
- FITMAN: Our pilot studies and examples so far are all individual cases – we don't have demonstrators of ecosystems actually demonstrating publicly the power of Manufacturing as a Service (MaaS).
- FIWARE: manufacturers were very sceptical but after experience they are more open to take the next step. We need to bring technology along with the business case.
- Industrie 4.0: companies now are aware and willing to take steps to avoid lagging behind. They want to integrate more IT also in customer services. The idea still has to come from the company/SME

IoT:

- There's a long way to go until plug and play mechanisms are a reality. Standards are part of the solution and are good for integrators. Plug and play works for USB ports, we should look more at such examples to transfer to all kinds of devices.

Smart cities:

- Smart cities is an emerging field where ICT is playing an increasingly important role. However, some barriers and challenges still exist, such as the need for standards that support the interoperability between different systems and the portability of applications from one environment to another. Since sensor networks are being deployed in many cities there is also an issue related to security. Depending on the kind of application this can also lead to data privacy issues. Different regulations across Member States do not help to scale and create a truly European market for Smart Cities.
- There's an overlap in platforms in smart cities (transport, health, energy, etc.). We need to push together all perspectives. There is a pyramid from citizen to a number of services with different (public and private) service providers with different platforms. Large scale pilots in SmartCities are needed as well as standards to enable exchange of data.
- Many SMEs are lacking information. It's difficult for an SME to find the right platform among many available platforms and technologies, and spend the time to become familiar with them. We need ecosystems that facilitate the interaction and engagement of SMEs so that they can cooperate and learn from each other.
- Data access is also a problem. For example, in the specific case of tourism it's difficult to gather data that is scattered among many different players. Measures and incentives to share data and open data to service providers are needed.

FOUNDRIES

- Manufacturing as a service: this already happens, e.g. "foundries" which manufacture semiconductors for clients. This allows SMEs to get into an industry, because the cost of manufacture, of installing the necessary equipment is very high, and offering manufacture as a service allows many businesses to share the costs. Other examples of industries where this could happen would help to understand how to migrate towards a service-oriented environment that brings benefits to different players, and especially to SMEs.
- Electronics: semi-conductor industries have been sharing foundries since long time ago. The equivalent nowadays could be 3D printings (sharing equipment, then you need to schedule services to organize all the jobs assigned to a pool of 3D printers)

INTEROPERABILITY:

- Telecommunications was given as an example of sector where many agreements in terms of standards have been achieved: no real concrete success in interoperability, but agreement on protocols/interfaces.
- From the SmartCat representative some questions on how to change the current "patterns" of manufacturing industry were raised. Will the industry move in the same direction as the telecoms? Manufacturers do not necessarily want to move towards a more open structure as it threatens their existing business models. More mechanisms to engage big players that have a pulling effect on others should be set up.

Interactive Session

After the open panel attendees were divided in 4 groups, each of them corresponding to a specific sector: Smart Cities, Energy, Manufacturing and Transport. The main objective was to map industrial needs & demands onto existing solutions and platforms, with a view on identifying the gaps. The session was short, but as result of the discussion of the groups we got a valuable list of challenges that should be addressed in the future. Road2CPS will work hard to bring these challenges to the relevant decision makers, including the European Commission, who will find these recommendations relevant to the definition of future actions. Posters providing the summary of the discusions are provided here for reference as well as some insigths on the concrete points raised by the participants.

SMART CITIES

Needs/Demand

- A citizen-centred approach is needed, which enhanced awareness raising activities
- Regarding the demand side, data access and open data are crucial and suitable algorithms for data management
- Accessibility of data is key (collection/storage), as are cloud technology, algorithms, data analytics, big data, more real-time fast performing algorithms to provide services to citizens
- Data structures and standards in data models are needed.
- Regulation should be simplified and homogenised on international / European level (including privacy, anonymisation of data)
- Affordable systems for security have to be put in place
- Infrastructure to support SmartCities is needed in various domains; it is partly offered providing wireless technologies / wireless sensors but needs to be improved to become seamless
- Procurement
- **Business models:** business value is a problem, there are various stakeholders, question who sells, who benefits
- Example infrastructure: Valencia initiative, imposing, recommending standard format for data
- If you have the data services will come
- Decision support/making tools/services for stakeholder from the city e.g. crises management, large event management
- **User centric**: Google now, info to users e.g. about traffic

Gaps

- IoT standards,
- Privacy converge with regulations
- Platform to gather and store data best practices, FIRWARE would be good, EU funding, incentives for platforms are required, we need to achieve convergence

ENERGY

Needs/Demand

- Compatibility with existing standards
- Pan European regulations
- Maintenance and upgrades systems
- Reliable Communication
- User acceptance of new platform
- Common security approach

Solutions

- Open call for "white hat" hackers (EU funding for initiative with 'professionals' to help, testing)
- Tenders
- Across the EU - Training programmes & certification are needed
- Multi-standard communication systems
- Super state regulator at EU level (not more regulation but joint regulation)
- Co-funded projects difficult, clear customer with clear mission, service delivery, customer relationship

Gaps

- Privacy control of data is crucial, new smart grids with more data circulating, open ways for new business models, but also need for privacy assurance of data
- Complexity of energy system, lack of clear accountability

MANUFACTURING

Needs/Demand

- Provision of IT and connected network service for last mile connectivity
- Connect service provider to consumer / independent from power and resources
- Awareness and discovery orchestration
- Common understanding (e.g. ontological)
- Market place (for services) (Data functionality, physical process
- Translation

Solutions

- Collaborative environment between the actors, providing engineering solutions
- Cloud manufacturing (partial solutions)
- Manufacturing as a service (MaaS) functionalities
- Generic infrastructures, different BM and actors
- Standard drafts (lots of things going on), no common agreement yet
- IoT solutions and architectures applied to manufacturing
- Legacy systems to be integrated, IoT could play a role

Gaps

- Awareness and discovery orchestration
- Common understanding (e.g. ontological description)

- Orchestration of services, integration of different services
- Market place (for services)
- Standardised and defined rules
- Service orchestrator to oversee and operate / Data functionality, physical process
- Translational link between projects, services and actors

TRANSPORT

Needs/Demand

- There are demands from citizens for seamless transportation but also from solution providers / car companies for infrastructures
- High utilisation, fast access, car sharing
- Road traffic management
- Development of autonomous vehicle is stuck with managing road traffic
- Safety issues coming from unforeseen interactions between systems
- Cyber security is an issue
- Autonomous testing and vehicle validation
- Accessing real information coming from the engine, the vehicle in service, e.g. real driving emission
- Cyber security threats
- V2V communication
- Smart infrastructure (road, signals,etc.)
- Real driving emission

Solutions

- AUTOSAR,
- Efforts on AUTOSAR platform with standardized elements to design and integrate function
- ASA M, ODS, OSLC
- Crystal with different interoperability standards
- Google traffic, TomTom, etc.
- Experience from logistics, e.g. DHL

Gaps

- Lack of standardized Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure/Infrastructure-to-Vehicle (V2I/I2V) communication, interoperability standards
- Consortia are already working on this but more effort is needed
- Lack of access to 'really smart'/complex environments/infrastructure to do testing
- Dedicated demo areas are good, but not yet complex enough
- Lack of data to simulate environments
- Integration platform for the measurement of the entire life cycle
- Using know-how from experiences (e.g logistics), how to involve knowledge

A synthetised view on two Platform Workshops

Summary of the "Platforms for connected Factories of the Future" Workshop

The "Platforms for connected Factories of the Future" workshop was organized by the European Commission, CONNECT Unit "Complex Systems & Advanced Computing" in cooperation with the European Factories of the Future Research Association (EFFRA).

The event took place in the context of the **EU-wide strategy for the digitization of European industry** in order to "ensure that all industrial sectors make the best use of new technologies and manage their transition towards higher value digitized products and processes". A key pillar of this strategy is precisely achieving **"Leadership in next generation open and interoperable digital platforms".**

The following initiatives were present:

- Platforms: RAMI, Virtual Fort Knox, FI-Ware based work in FITMAN and BEINCPPS, Industrial Data Space, IIRA, CyPros, ROS, Arrowhead
- Non-platform initiatives (relevant for the discussions): International benchmark (Inbenzhap), sCorPius, Logistics 4.0 and Internet of Things, AIOTI (Alliance for IoT innovation).

The table below gives an overview and classification of some of the relevant platform-oriented activities

Name system	Type	Domain	Status	Level of standar-disation	Openness	Value creation	Ecosystem	Stakeholders	User range	Test beds available
RAMI	Operational	Manufacturing industry	Reference Architecture	High	Open	With system		Industry, Software vendors	Vertical	Yes
Virtual Fort Knox	Technological, operational	Manufacturing industry	Implemented	High	Open	With and within system	Yes	Industry, Software vendors, Government	Vertical	Yes
BEinCPPS	Technological	Manufacturing industry	Under construction	Low	Open	Within system	Yes (5 ecosystems)	University of Milan, Big industrial companies, SMEs, EC	Horizontal	Yes
FIWARE - FITMAN	Technological	Manufacturing industry	Implemented	High	Open	With system	Yes	Industry, Software vendors, machine producers	Vertical	Yes
Industrial Data Space	Technological, operational	Pharmaceutical, Automotive, Retail, and Production industry	Reference Architecture	High	Closed	With system	Yes	Big (industrial) companies, Government,	Horizontal	Yes
IIRA	Technological	Energy, Healthcare, Manufacturing, Public Sector, Transportation	Reference Architecture	High	Open	With system	Yes	Business decision makers, System engineers, product managers, developers	Horizontal	Yes
CyPros	Technological, operational	Manufacturing industry	Reference Architecture	Low	Open	With and within system		Manufacturing industry (big and small companies)	Vertical	
Arrowhead	Technological	Manufacturing industry, Smart Buildings and infrastructures, Electro mobility, Energy (production and Virtual Markets of Energy	Reference Architecture	High	Open	With system		Service providing and consuming companies in diverse sectors	Horizontal	

Source: Draft report Workshop "Platforms for connected Factories of the Future"

Main outcomes of disscussions were:

1) In which **domains** platforms are most likely to bring advantages to EU industry (e.g. the "operating system" of the connected factory of the future)? Which are the **groups** that should be brought together in a multi-sided market?

   In terms of **domains**, these ones were mentioned:
   - Network-based Programme Logic Control systems (PLC) (delocalisation of control technologies)
   - Supply chain management / Digital market environment for manufacturing services
   - Product Lifecycle Management (PLM) (strong focus on product lifecycle)
   - Product-Process-Automation (stronger interconnection of automation technologies and product/process life-cycle management technologies).

   Platform areas where work is needed or at least should be considered when talking about platforms seem to be (according to the workshop): **openness and interoperability, connecting existing standards, and connecting existing commercial platform**s, from a functional point of view we should look at **sharing of knowledge** and the **improvement of efficiency and productivity**. Finally, concerns were raised around the following topics: r**eliability of data, data ownership, control and protection of data, privacy, trustworthiness, independency**, and **ease of use**.

   Stakeholders that should work together include:
   - Manufacturing industry (for their validation capacity and technology pull)
   - IT companies (for their service development capacity and technology push, not only big players, but also SMEs)
   - Software and application developers
   - Platform managers
   - Shop floor owners with specific problems (SMEs)
   - Authorities auditing the trustworthy and privacy of data, (public authorities, chambers of commerce, local authorities, etc.) and
   - Brokers or orchestrators

2) How would you build the **ecosystem** around the platform?
   a. What are **representative companies** that will make up the ecosystem?
   b. Which **business interest** would they have in being part of the ecosystem?
   c. How would you **attract** them to participate in the development of the platform?

   Some concrete examples of companies within the aforementioned groups were mentioned (such as Siemens or ABB) but in general the ecosystem should be inclusive, for example by considering SMEs and startups as part of the innovation environment. More important is the ability to remain open and create opportunities for all players without pre-defining or imposing business models. The ecosystem should be driven by real industrial needs, leading to competitiveness and profitability,

including as part of the objectives the scalability aspect. Both the platform and the services on top of that should be distinguished.

3) What are the **key building blocks and components** (including proprietary/commercial technologies and common/standardised frameworks) for the domains identified? What are you prepared to collaborate/ join forces on platforms? What would you rather compete on?

   The following building blocks were highlighted: Peer-to-peer communicating systems, Distributed intelligence on a real-time runtime; Control Algorithms, Safety; Data protection, privacy and security; Capacity for traceability; Wireless connectivity; Components and machines; New generation "PLCs"; Interoperability and data ownership; Semantics, ontologies, taxonomies; Low cost communication modules; Network providers; No monolithic system; Institutionalisation; Respect for commercial mechanisms; Validation

4) Which **technical activities** are needed for the development of a platform?
   a. Derive and maintain reference architectures?
   b. Develop and validate reference implementations?
   c. Support test-beds, pilots, demonstrators and validation environments?
   d. Support standardisation activities?
   e. Anything else (please specify)?

   Answers to questions a) to d) were positive. In terms of additional activities, some of the priorities pointed out were related to education and digital skills development, definition of economic conditions of use, usability and consideration of manufacturing requirements.

5) How do we best complement and reinforce national and industrial approaches/initiatives with EU R&I activities under Horizon 2020?

   Best practices or workshops like this one were mentioned as positive activities in that direction, recognizing that there is no coherent EU plan at this stage and some work is needed; leadership, according to the report, should come from the EC even though national representatives should also be engaged.

Common and differential points of the Road2CPS workshop

Road2CPS, as in the previous case, also analysed some of the ongoing initiatives on platforms to understand the baseline. Representatives of various relevant horizontal as well as vertical platforms were invited: Crystal, Arrowhead, Virtual Fort Knox, FITMAN, FIWARE, Industrial Ring 4.0 (a platform for the Catalan Smart Industry) and HANA. The main purpose was extracting the elements that can lead to a successful strategy on platforms in Europe, such as which technologies should be considered, but also what additional elements (of non-technological nature) should be addressed. Learning experiences are crucial to define the next steps. This workshop was shorter than the one held in Brussels; therefore, the number of examples was more limited, added to the fact that we also wanted to give priority to open

discussions among all the participants. Two differential elements should be highlighted with respect to the former workshop:

a) Discussions were not focused only on platforms for manufacturing, but on **platforms for any domain where CPS plays a major role**
b) Recommendations and outcomes did not only address the European Commission but also other decision-makers. Lessons learned should be valuable input for industrial players willing to invest in platforms, as providers or users.

With that context in mind Road2CPS organized a second panel of speakers addressing the requirements and needs from the demand side, with representatives of domains such as manufacturing, automotive, energy and smart cities. Building platforms per se, as a pure technological exercise, does not make any sense. Thus, our main intention was to understand to which extent current platforms cover existing industrial requirements. The afternoon turned to be the *space* to align supply and demand and discuss platforms that could already make an impact on the competitiveness of companies working in a specific sector of those targeted by the workshop as well as to identify **existing gaps that need to be addressed by future actions**.

Examples of main areas that require further work and attention have been pointed out to be:

- **Openness and multi-sided markets**: It's no longer the case that one single company is able to do everything. Our environment is now much more complex; we talk about systems of systems, where dependencies between the different elements of the ecosystem are very high, and where a lot of players are involved. This happens at technical level, but also at service level. Many big players struggle with innovation; they are not agile enough to reduce time-to-market and release new innovations. That is why in the last years we have increasingly seen the term "open innovation". There are many degrees of openness. Maybe we cannot say to which degree each industrial sector has to be open, but at least we can anticipate that successful ecosystems will be those that provide opportunities for different stakeholders and not only for the ones providing the "platform". Relying on the agility of SMEs and startups can be a good asset for many industries, especially if we consider that most sectors in the EU are characterized by a high percentage of contributing SMEs. One way to do so is providing access to open APIs[11], which enable different stakeholders to build applications and services on top of the platform/infrastructure (or even to develop other technology blocks on top of the baseline platform). We can see examples of success stories of both open source (ex. Android) and proprietary systems (ex. Apple), but in all cases the ecosystems are composed by a varied group of stakeholders that get benefits from their interaction with the platform.

- **Interoperability**: it is quite typical that we get surprised about the diversity of platforms we have been working on. Sometimes the discussion translates also to the amount of standards

[11] API stands for Application Programming Interface

that we have generated. However, the sad story is that the degree of interoperability between most of them is very poor if not absent. Open standards can greatly contribute to change the story, but furthermore, Europe needs to have a strategy to understand which standards have to be pushed forward and which ones should be ignored. It is not a question of creating more standards (in most cases) but of deciding strategically which ones should be embraced. The decision should come as a result of industrial alliances that could make EU players stronger in front of their competitors. Consider, for example, the alliance between many EU car manufacturers on digital maps to realize the concept of autonomous driving; in this case industries cooperate at EU level to be well positioned in the future, in order to compete with players like Apple or Google who are capable of gaining an important market share. In some industries de facto standards can be a faster way of creating markets and contributing to the Digital Single Market (DSM). Finally, if we talk about interoperability we should not forget that data models play an important role too. A promising initiative working in that direction is OASC (Open and Agile Smart Cities), which aims at creating a truly European Market on Smart Cities[12].

- **Big Data**: we started this analysis by pointing out the way Internet technologies have dramatically changed many industries. One of the major changes is that the value for many companies is not anymore in physical assets, but in data associated to the elements of the value chain. Consumers can access many products and services for free, but were accustomed to paying for them in the past (newspapers, music, movies are just few examples of this trend). In exchange for these free services, companies get access to consumer data, which can be monetized in different ways by the companies (publicity is the most obvious way). Almost all the presentations and the discussions during the workshop, whatever sector they referred to, included data as major asset for the future. The example of car manufacturers and mapping technologies for the autonomous car (see the previous point) points out very clearly that the "future car" will be fully dependent on data. This trend towards data-related industries needs to be tackled in the appropriate way, since it could be a source of future business for Europe, or become a reason to hand over market share. A lot of challenges around data exist (data curation, baseline infrastructure, real-time management, etc.). Players in this domain, including the EC, should relate to the newly-created Big Data Value PPP to ensure a coherent implementation of those challenges.

- **Security/data protection**: whilst data opens new business opportunities it makes complex ecosystems very vulnerable to hackers. Are data sets reliable nowadays? Who is liable if a wrong decision is taken as a result of using third-party data sets? This is just one of the sides of the coin. Aspects related to security, as highlighted by speakers and participants in the workshop, especially if we address mission-critical systems, is one of the areas where most efforts and investments should be made.

[12] Further information about OASC can be found in http://connectedsmartcities.eu/open-and-agile-smart-cities/

- **Critical mass**: In the first point we made reference to multi-sided markets and the ability of the ecosystem to generate benefits to all the contributing parties. Critical mass can be a success factor in most cases (maybe this does not apply to all industries, but most of the examples that come to our mind fit into that). Why is Apple so popular? A company that wants to develop an application chooses to use their platform because it opens the doors to a huge market; at the same time Apple needs a rich variety of high-quality applications to make their products more attractive to the final consumer. This win-win relationship increases the potential market for both of them: the more people buy an Apple device, the bigger the market is for application providers. We have some examples in Europe where this element has been well understood. The FIWARE platform was a technology concept in the beginning, but it has evolved towards a rich ecosystem of technology providers, FIWARE users (app developers such as SMEs and entrepreneurs, but also big companies that can develop their services reducing cost and time-to-market), data providers and application sponsors/potential customers. Reasons for all the stakeholders to enter the ecosystem are clearly stated and the contributions of the different stakeholders enrich the overall ecosystem, making it more attractive for the others. However, reaching a critical mass of contributors and adopters does not happen easily. Therefore, it is important that investments are not only made in building platforms, but also – and more importantly - in creating such ecosystems and making sure that adoption happens before other (non-EU) competitors enter the market.

  Experimentation/Test beds: many customers in many sectors claim the need for experimentation or validation environments that help them to accelerate product/service deployment. EU companies should be able to deploy very quickly and test all kinds of elements (such as scalability) before deploying their solutions in a real production environment. This should be possible at EU level and should be an asset to save time and resources. This is particularly important in the case of SMEs, which cannot afford investing in complex test beds or simulation environments.

Even though we are all conscious that some activities require time, it is extremely important for Europe to react quickly. Definition of actions and instruments to implement them should take this imperative requirement in consideration.

Other sections of this document reveal the details of the presentations from both sides, supply (platforms) and demand (application domains or sectors), as well as the insights of the discussions held in the afternoon around platforms as a whole (and the associated challenges) together with the parallel sessions that targeted the alignment of supply and demand in specific sectors. The panels built by the experts around **smart cities, energy, manufacturing and transport** provide a good overview of the existing offering in those sectors, but also about the demands, and more importantly the gaps or existing needs that are not well covered yet.

Concluding Remarks

Participants agreed that this was a successful and very useful workshop. There was a general agreement on main requirements and challenges, including:

- openness
- interoperability/standardisation
- (suitable degree of) regulation, privacy, safety & security
- business thinking
- involvement of customers
- creation of ecosystems around platforms
- tools and mechanisms for pan-european testing and experimentation, among others.

Participants pointed out that there is a need to further elaborate on such discussions, exchanging views and aligning supply and demand side of platforms. In a next step, the direct platform users / customers should be involved more deeply, as it is crucial to reply to real needs and create a relevant value proposition (avoiding pure technology-push approaches). EU funding for this topic is a need to accelerate the process and has proved to be effective in the last years in terms of maturing platforms as well as strengthening the related ecosystems. Such investment is seen to be crucial to bring main actors across the industrial sectors and various disciples together, to jointly face the challenge. In order to bring EU-platforms to a successful implementation we need to ensure that there is collaboration in research and development, openness in finding new business opportunities, de-fragmentation of initiatives and efforts, constructive dialogue on conveying themes (regulation, privacy, legal frameworks, etc.), building and sustaining the ecosystem, and involving SMEs and getting the commitment of large industry.

Participants

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