AIOTI

ALLIANCE FOR INTERNET OF THINGS INNOVATION

Report

AIOTI WG11 – Smart manufacturing

2015

Introduction

In future, all forms of advanced industry will have to become more data-driven and more "intelligent" in order to compete effectively. This intelligence will also rely on advances through IoT, since data and intelligence will come from advanced connected objects that provide sensing, measurement, control, power management and communication, both wired and wireless.

Smart Manufacturing is projected to be the largest potential opportunity in terms of size IoT spending, followed by Smart Homes and Smart Health.

In fact, manufacturing is undoubtedly one of the key IoT markets today. The proliferation of machine-to-machine devices is leading to an enhanced role played by smart products and smart services and to the emergence of global plant floors and autonomous factories.

The WG 11 provides an overview

- of the relevance of IoT in manufacturing
- of European research and demonstration activities.

This report has to be seen as "work in progress".

Executive Summary

The European manufacturing industry is constantly undergoing through a modernization process. IoT technologies have already entered into manufacturing and this trend will ever increase. Europe's manufacturing industry is investing vehemently in its modernization, which as said includes the in troduction of not only IoT, but also CPS and the exploitation of big data.

Since many years, both European as well as national public support programmes are supporting EU manufacturing industry to embrace IoT technologies. This WG 11 report gives an overview of these activiites and outlines possible future activities.

At EU-level, the biggest initiative that combines "IoT & manufacturing" is the Factories of the Future Public Private Partnership, launched in 2008/9 as part of the Economic Recovery Package. Projects and results stemming from the FoF PPP can all be accessed through the EFFRA Innovation Portal.

Within the Factories of the Future PPP, the FoF 2016-2017 FoF calls were published. The total public EU funding available is €278 Million (submission deadline is 21 January 2016). In many of these calls IoT technology can have its place, please see here an overview of the 2016-2017 calls.

This concerns in particular call FoF 11, with an envelope of 53 million Euros and FoF 12 I4MS. Please read also the background information on this FoF 11 call. However, it should be stressed here that these are not Large Scale Pilots.

Beside the FoF PPP, similar initatives exist at national level, an overview is provided here: https://ec.europa.eu/digital-agenda/en/news/european-co-operation-innovation-digital-manufacturing

While the FoF PPP is a manufacturing-centred EU initative (the manufacturing and supply chain management process is in the focus, with IoT as one of the enablers), there are many more activities at EU level which do not have manufacturing as the focus per se, but nevertheless address also IoT in manufacturing. These are:

- FI PPP Use Case Trial project FITMAN (Future Internet Technologies for MANufacturing industries www.fitman-fi.eu),
- Artemis/Ecsel,
- The IERC cluser and the Digital Business Innovation Community

All these activities have helped to better describe the challenges and opportunities of IoT in manufacturing and have stimulated the adoption of IoT by Manufacturing Industry.

AIOTI - WG11

Table of Contents

1 Context and the puropose of this document

The European manufacturing industry is a key economic sector and key employer for Europe: it generates a positive trade balance with the world, it accounts for 80% of private R&D investments in Europe, it provides jobs to more than 20 million European citizens and more than 30 million jobs if the service- related activities of manufacturing are included.

In the future, all forms of advanced industry will have to become more intelligent in order to compete effectively. This intelligence may rely on advances through IoT – as it comes from advanced connected objects that provide sensing, measurement, control, power management and communication, both wired and wireless.

Following a study from IDC, Smart Manufacturing is projected to be the largest potential opportunity in terms of size IoT spending, followed by Smart Homes and Smart Health, which represent respectively 91% and 90% of the largest market. In fact, manufacturing is undoubtedly one of the key IoT markets today. The proliferation of machine-to-machine devices is leading to an enhanced role played by smart products and smart services and to the emergence of global plant floors and autonomous factories.

The historic split between cheap mass-produced products creating value from economies of scale and more expensive customised products will be reduced across a wide range of product types. Direct customer input to design will increasingly enable companies to produce customised products with the shorter cycle-times and lower costs associated with standardisation and mass production. To achieve this level of flexibility for mass customization, intelligence must be built into even the smallest steps of the process. In car manufacturing, for instance, there may be more than two million individually orderable configurations of the finished good, and countless changes in assembly may be needed to cope with all the variations. Even a seemingly straightforward tool such as a screwdriver needs to automatically adapt its torque limitation to the part, which may be steel, carbon or plastic in different configurations. Intelligent monitoring also enables better predictive maintenance, enhancing the stability and safety of the production process. Vibration sensing, for example, can give an early warning when motors, bearings or other equipment are in need of maintenance. Algorithms enable mechanical engineering firms to predict possible machine outages. Hundreds of data points help optimize numerous production workflows. Well-maintained machines are also safer for workers, and there are other safety benefits that can result from more intelligent equipment as well.
Drawing on traffic and requirements data, today's logistics providers can adjust the routes for their transportation fleets in real time. Physical production processes are increasingly at the centre of much wider value chains. Intra-plant and extra-plant logistical processes are integrated reducing the cost for warehouseing to Zero. Interconnecting the entire value chain via mobile or fixed-line high-bandwidth telecom networks synchronizes supply chains and shortens both production lead times and innovation cycles.

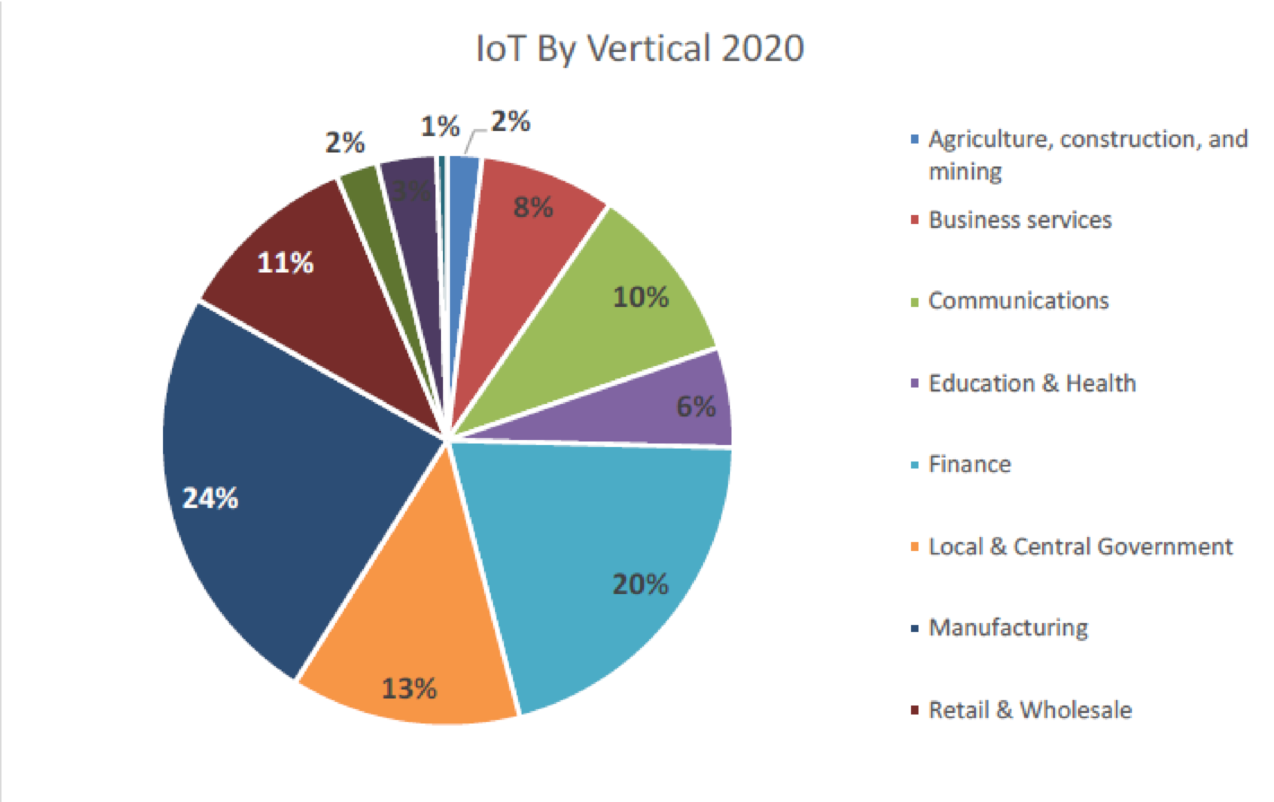
IoT has already found several applications in both process and discrete manufacturing. All supply chain/warehouse management processes such as demand management, order fulfillment, manufacturing flow management and return management can be tracked in real time to ensure the highest efficiency at each step. The production line, and the operations related to its maintenance, can also benefit from IoT-based wireless inspection tools allowing for real-time control of performance, durability, and safety of the products they produce. Manufacturing Operations is therefore the number one use case in smart manufacturing today in Europe, followed by Production & Asset Management, which uses IoT to monitor and maintain assets (e.g., industrial manufacturing devices) that are part of the production value chain with the end goal of improving process efficiency for manufacturers.

The smart factory represents a fundamental change in how production processes are set up and organized. The smart factory also serves to decentralize manufacturing, provide greater intelligence where production activities take place, and create an overall system that is cognitive and self-healing.

Sensors are the eyes and ears of the smart factory, and as such they will be everywhere. Besides conserving power, embedded sensing systems must be small, inexpensive and rugged, with industrial qualification for vibration and temperatures up to 125ºC.

Communications, both wired and wireless, is frequently the gating factor in systems for automated manufacturing, since it determines the amount of computation that can be employed and often defines power requirements. Future industrial communications modules will have to operate on less power, be more highly integrated and offer greater flexibility in terms of protocol support, power schemes and peripherals. Increased bandwidth will also be important, especially for wired communications, pointing to greater use of Gigabit Industrial Ethernet, along with integrated protection schemes to comply with industrial standards.

Manufacturing has the biggest pull factor for IoT, as described in the graph.



Source: IDC 2014

The **purpose of this WG 11 report** is to explain how in manufacturing IoT technologies are used today and how they will be used in future. The report presents an overview of ongoing activities supporting Innovation through the use of IoT technologies in Manufacturing.

The WG 11 report looks at the enormous innovation potential of IoT technologies when fully adopted not just in the production of physical goods, but in all activities performed by Manufacturing Industries. This scenario is described in detail in chapter 2.

Chapter 3 describes experiences and achievements from the ongoing FP7 and H2020 projects and the circulation of novel ideas, challenges and innovative approaches at H2020 Factories of the Future, looking for the establishment of liaisons and synergies to tackle a coherent body of knowledge and practices towards innovation within the EU R&D community and industry.

Chapter 4 present **current and future** funding opportunities in Horizon 2020

1 IoT in the Factories of the Future

The convergence of cloud and IoT technologies will facilitate the development of factories of the future and the realisation of digital manufacturing. These future manufacturing plants will comprise numerous devices, physical and virtual smart objects, internally and externally interconnected, to dynamically enable configuration and monitoring of the operational capabilities of the plant, or networks of plants, quality control and efficiency improvement. Additionally, the traditional, fragmented processes of design, production and customer fulfilment will be replaced by a close-loop management of the end-to-end design-to-customer fulfil, where cycles are shorter and products are designed based on customer requirements (customer-focused manufacturing).

Here, the processes do not finish with product delivery; the product-service provides information for the maintenance services and for continuous design of products and processes. The sensors in machinery and manufacturing services developed will facilitate the operational performance model for predictive maintenance of the machinery.

A global plant floor requires that the network of production facilities operates as a single virtual plant. Operations require individual plants' centralization control capabilities based on real-time information, multi-plant manufacturing execution systems (MMES) and major integration and visibility on supply customer ecosystems based on enterprise manufacturing intelligence (EMI) platforms. Additionally, increased control and supervision requires the improvement and acceleration of decision-making capabilities based on real-time information, interoperability between systems and collaborative decision-making.

This environment requires adaptive, scalable and interoperable architectures to support real-time data for operational management, supply-chain execution and collaborative decision-making. Scalable and multi-enterprise architectures are needed for: managing the operations of networks of organizations in the same supply chain; connecting MES and business processes in real time; establishing new business models based on secure cloud services. Interoperability between business processes and operational levels must be improved through a common information model. As the IoT expands, cybersecurity will have to be considered at every point, and common, sector-specific threats and countermeasures will need to be identified.

Security requirements that are unique to CPS will have to be determined. A risk management framework and methodology to enable, assess, and assure cybersecurity for adaptive and smart manufacturing systems will have to be established; adaptable computational and storage tools including methods for protection and security of intellectual property will have to be identified, developed, and deployed. Critical control functions of a CPS system must be protected from cyber-attacks using more realistic attack models than the one typically used to assess control reliability. Novel information security concepts and approaches, such as turning properly constructed interfaces from attack surfaces into cyber-defence surfaces, offering explicit and implicit design guarantees, and providing security as a class of interface guarantee, will have to be explored. It will be much more effective and ultimately cheaper to secure smart manufacturing systems at the engineering design phase, rather than later. The economic and technical viability of possible integration with legacy systems as well as existing open source applications and tools will also have to be assessed.

1.1 IoT & Cyber-Physical Production Systems

As illustrated in the previous Section, the factories of the future will be subjected to a profound transformation. Such transformation will not be limited to the physical world and the manufacturing line.

A digital revolution will also take place in the digital domain. Factories will witness the prevalence of Internet technologies also at manufacturing level; the mass deployment of Cyber-Physical Systems for monitoring & controlling and will see the use of the Big Data capabilities everywhere (world, enterprise, shop-floor).

The role of ICT will be instrumental addressing the increased complexity that manufacturing industries will have to face at many levels; e.g. increased product customization, largely dynamic delivery requirements, agile and rich collaboration patterns and networks of different technical disciplines and organizations.

These requirements coupled with the advent of innovative manufacturing technologies such as additive manufacturing or high precision zero-defect manufacturing call for robust interoperability solutions that integrate the factory with the environment, i.e. the urban context, data integration standards amenable to IoT and linked tool chains that move away from vendor-lock-in, monolithic systems and envision mobile & cloud native support. The development of such smart manufacturing environment is highly dependent on the development and integration of IoT capabilities in an industrial context. Recalling a recent road-mapping effort; i.e. Pathfinder, IoT-based manufacturing must abandon the current classical approach to industrial automation – see Figure below.

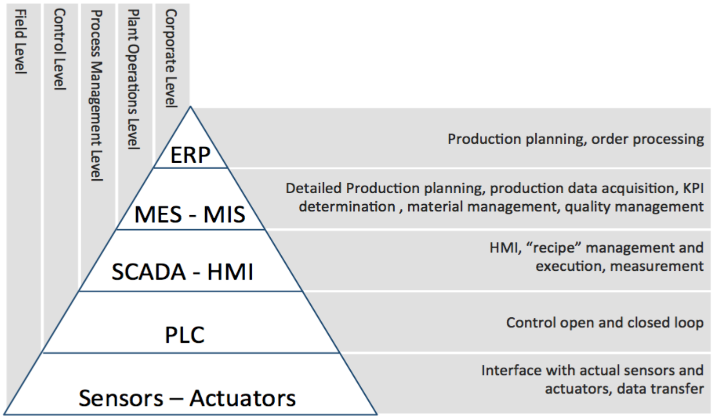


Figure 1.1 Traditional automation pyramid.

The current approach is deemed by industrial key players and RTD experts to be inadequate to cope with current manufacturing trends and needs to consequently evolve. The intrinsic existence of smart interconnected devices defies the concept of rigid hierarchical levels, being each one of these devices capable of complex functions across all layers. Thus it should be introduced an updated version of the pyramid representation, where the field level features smart-objects capable of articulated functions (thus in contact with all the pyramid layers) while still the hierarchical structure is preserved. This leads towards the Industrial IoT automation pyramid that will be the basis for future Cyber-physical production systems (CPPS).

1.1.1 *CPPS architectures design drivers for scalable, adaptive and smart manufacturing systems.*

Future ICT tools and technologies will give companies multiple opportunities, such as increases in efficiency and quality throughout value chains, the exploitation of additional markets, and manufacturing that is highly responsive to changing market and customer demands. Smart manufacturing will exploit advances in wireless sensor technologies, machine-to-machine (M2M) communication and ubiquitous computing, that would allow track-and-trace and monitor each individual stage of the production

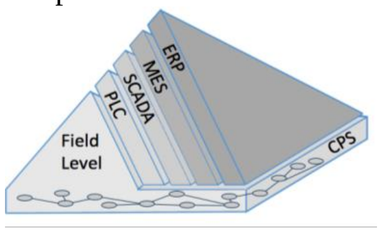


Figure 1.2 Cyber-physical production system (CPPS) automation pyramid.

Thus, CPS will provide a shared situational awareness to support network-centric production by closing the loop between the virtual world and the physical world. In order to exploit the full potential of CPS, various existing ICT systems have to be integrated, adapted to the industrial needs, and deployed on the shop floor:

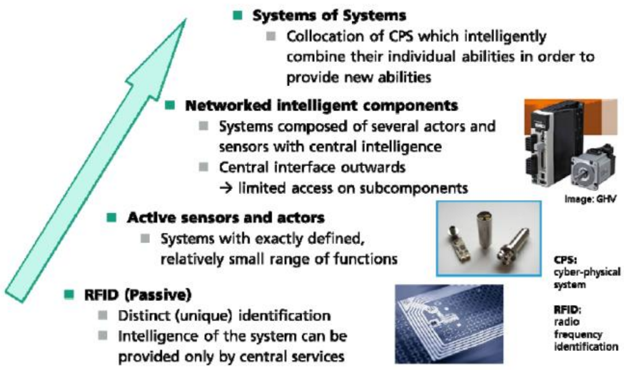


Figure 1.3 - Stages of development in CPS capability.

The evolution and design of ICT architectures to meet the demands of future CPPS capable of delivering the manufacturing competitive advantages described above will be driven by the **FISAR** design principles (**F**lexible system-component integration, **I**nteroperable among systems and components, **S**calable, **A**daptable to varying governance structures, **R**eal-time capabilities)**.**

The design and development of CPPS is intrinsically complex with characteristics unique to the deployment of IoT technologies in an industrial context. The requirements of the CPPS require to develop the material and software components, middleware, operating systems beyond the existing technologies. Because they interact directly with the physical environment, hardware and software must be reliable, reconfigurable, and, for the most critical, be certified, from components to the whole system. These complex systems have to present one degree of reliability / confidence which is lacking to most of the current infrastructures. The oversizing is at present the way the most used for the certification of safe system.

Research is nowadays organised by disciplines and the systems are developed with a large set of formalisms and modelling tools without links between them. Each part of a system highlights characteristics without considering the other components and the systems as a whole. Typically a specific formalism will represent either a cyber-process or a physical process but not both. The expertise is split to the detriment of the productivity, the safety, the security and the efficiency of the system. Although this approach can be enough to support a vision of the CPS based on a set of individual components, it raises a problem for the verification, the safety and the security at system level as for the interactions between components. To allow a design and a fast deployment of the CPS, it is necessary to develop innovative approaches to define architectures which make possible a transparent integration of the elements of control, communication and processing.

Making manufacturing smart implies that on one hand all devices in factory have to become smart, or smarter, and furthermore that they cooperate in order to provide smart functionalities. But these new functionalities shall not come at the price of decreasing plant safety. And in a connected world, safety necessarily implies cyber-security. The biggest challenge is that flexibility, safety and security requirements are usually competing each other, refraining many smart manufacturing ideas from becoming a reality. So the challenges for the engineering of CPPS are significant and range from the actual complexity of modular systems of systems engineering but also deal with the performance and reliability of SOA-EDA architectures, which increasingly demand a better integration between IoT and cloud domain. Moreover, cyber-security and in some cases mix-criticality of the system impose additional constraints that cannot be left aside.

Please note:
This chapter 2 “IoT in the Factories of the Future” is based on the article published in following book:
IERC 2015 Book, Chapter 5.

2 Ongoing research and innovation activities in IoT for Manufacturing

Research and Innovation activities concerned with “IoT for Manufacturing Industry” are being developed in different Workprogrammes (FP7 and H2020), different PPP initiatives, different Calls and Objectives.

In the following, we tried to make an inventory of such initiatives following the EC organisation and FP7/H2020 structure.

In the first sub-chapter, we are addressing the EC-funded initiatives under the **Factories of the Future PPP.**

In this sub-chapter the main focus is on technology adoption and it comprises not just technology-oriented issues (such as resilience, performance, security) but also market-oriented issues related to business models, organisational aspects, as well as soft issues such as users’ acceptance, skills gaps, education and formation.

Sub-chapter two provides a report of Regional and National programmes that relate to the Factories of the Future PPP.

In sub-chapter three, as an example of a general purpose digital platform, to be specialised for different domains such as Energy, Healthcare, Multimedia, Logistics and Manufacturing, we briefly indicate the Future Internet PPP (www.fiware.org), its Generic Enablers (http://catalogue.fiware.org/) and their specialisation for the Manufacturing industry in the FITMAN Phase II Use case project (www.fitman-fi.eu).

Another source for information is given by the research clusters in the domain of Cyber Physical Systems (CPS) and Systems of Systems (SoS) which are described in sub-chapter four together with their innovation initiative called Smart Anything Everywhere
(SAE http://smartanythingeverywhere.eu/).

Sub-chapter five reports the most relevant projects and initiatives under the ARTEMIS Joint Undertaking (JU http://www.artemis-ju.eu/), now become ECSEL JU (Electronic Components and Systems for European Leadership http://www.ecsel.eu/), in which the Smart manufacturing industry represents one of the most relevant application domains of these technologies.

In sub-chapter six, projects mapped by the IERC cluster (European Research Cluster on the Internet of Things http://www.internet-of-things-research.eu/) and of the FinEs cluster will be described.

In the the last chapter we provide EC-commissioned studies and market analysis relevant for our domain.

2.1 FoF PPP

The Factories of the Future PPP represents the biggest initative in the EU which deals with the modernization of manufacturing. IoT technologies are also addressed by the FoF PPP:

All the FoF projects are duly described in the EFFRA Innovation. Here we highlight especially:
- CSAs focussing on roadmapping exercises,
- the RIAs funded under the first H2020 call in the ICT workprogramme about process optimisation of manufacturing assets,
- the RIAs funded in the NMBP workprogramme about product service systems design using manufacturing intelligence (FoF.2014.5),
- the FoF.2015.8 and FoF.2015.9 projects.

2.1.1 Full overview in the EFFRA Innovation Portal

All FoF projects are included on the EFFRA Innovation Portal (www.effra.eu/portal) Progressively, also projects that are not part of the FoF PPP are included on the portal. A project cluster 'IoT' has been created in order to obtain a list of all the projects in that cluster.

Are you involved in a Factories of the Future project? Then please make sure that your project is mapped.

Find and sort

Search character string in acronym | Free text (project summary) | Sort by: acronym | Sort order: Descending

Call topic | Instrument

Project clusters: IoT | Monitoring | Programme

Submit

Pages:: **1**

Result of your query: 16 Projects

New project

Project Acronym	Title	Project end date	website	EC contribution	Duration
sCorPiuS	European Roadmap for Cyber-Physical Systems in Manufacturing	2017-02-01		610,014	24
ROAD4FAME	Development of a Strategic Research and Innovation Roadmap for Future Architectures and Services for Manufacturing in Europe and Derivation of Business Opportunities	2015-10-31	road4fame.eu/	859,968	29
	Clustering	Road2CPS, CPSELabs, Pathfinder, LinkedDesign, Co-factor, Reborn, Transparency, IRamp, Effective, I4MS, Photonics4All, CPSoS, CyPhERS, ARTEMIS-IA,... (ActionPlanT)			
	Standardisation	- Road4FAMR is aiming at giving recommendations for standardisation efforts			
PSYMBIOSYS	Product-Service sYMBIOtic SYStems	2018-02-01	http://www.psymbiosys.eu/	5,996,304	36
	Clustering	PSYMBIOSYS is included in the Area 3.6.2 of the Factories of the Future named "Innovative product-service design using manufacturing intelligence. Six projects are included in this cluster.			
	Standardisation	- The project will contribute to Standardization by using Service Modelling TOOLBOX, an asset produced by MSEE project (theme FoF-ICT-2011.7.3 - Virtual Factories and enterprises, grant agreement no: 284860), which ended September 2014). The service Modelling TOOLBOX use a language SML (Service Modelling Language) which is proposed to CEN-CENELEC in this moment to standardization. The standardization process has already started , CEN has issued a procedure proposing the generic steps of the standardization process for a European Norm the stage 4th has been reached: to produce a Working Document which is an initial description of the standard and to spread it in TC 310 (Technical Committee) for comments. BIBA and Polimi are involved in Quantum Lifecycle Management (QLM) research activity. The QLM is the name of a Work Group of The Open Group, a global consortium with more than 400 member organizations, where members work to establish open, vendor-neutral IT standards and certifications in a variety of subject areas critical to the enterprise. In particular, the QLM Work Group provides the framework to develop and consolidate open standards necessary to enable lifecycle management to evolve beyond the traditional limits of Product Lifecycle Management (PLM). QLM aims to support the Internet of Things (IoT) paradigm, where products can have many degrees of intelligence.			

2.1.2 *Projects involving roadmapping activities:*

Project Acronym	Title	Project end date	Website
PATHFINDER	European research and innovation agenda for future simulation and forecasting technologies	2014-11-30	http://pathfinderproject.eu
ROAD4FAME	Development of a Strategic Research and Innovation Roadmap for Future Architectures and Services for Manufacturing in Europe and Derivation of Business Opportunities	2015-10-31	http://road4fame.eu/

2.1.2.1

sCorPiuS	European Roadmap for Cyber-Physical Systems in Manufacturing Industry (CPS4MFG). Consensus building, technology awareness and communication are accompanying the main roadmapping exercise covering not just CPPS but the CPS adoption in PLM, Warehouse Mgmt, Logistics and Retail	2017-01-31	

2.1.3 *FoF.2014.1 Process optimisation of manufacturing assets (research and innovation projects)*

Project Acronym	Title	Project end date	website
PREVIEW	PREdictiVe system to recommend Injection mold sEtup in Wireless sensor networks	2018-01-01	www.preview-project.eu
CREMA	Cloud-based Rapid Elastic MAnufacturing	2018-01-01	http://www.crema-project.eu
C2NET	Cloud Collaborative Manufacturing Networks (C2NET)	2018-01-01	http://c2net-project.eu/

2.1.4 FoF.2014.5: Innovative product-service design using manufacturing intelligence (research & innovation projects)

Project Acronym	Title	Project end date	Website
DIVERSITY	Cloud Manufacturing and Social Software Based Context Sensitive Product-Service Engineering Environment for Globally Distributed Enterprise	2018-02-01	https://www.diversity-project.eu/
FALCON	Feedback mechanisms Across the Lifecycle for Customer-driven Optimization of iNnovative product-service design	2018-01-01	http://www.falcon-h2020.eu/
ICP4Life	An Integrated Collaborative Platform for Managing the Product-Service Engineering Lifecycle	2019-01-01	http://www.icp4life.eu/
MANUTELLIGENCE	Product Service Design and Manufacturing Intelligence Engineering Platform	2018-02-01	http://www.manutelligence.eu/
ProRegio	Customer-driven design of product-services and production networks to adapt to regional market requirements	2018-01-01	http://www.h2020-proregio.eu/
PSYMBIOSYS	Product-Service sYMBIOtic SYStems : a new collaboration paradigm between Product and Service resources for a more efficient and effective design of innovative PS Systems	2018-02-01	http://www.psymbiosys.eu/

2.1.5 FoF8 –2015: ICT-enabled modelling, simulation, analytics and forecasting technologies

The call topic addressed "big data" from smart sensors, interactivity, real-time, etc.
The call topic addressed "big data" from smart sensors, interactivity, real-time, etc.

Project Acronym	**Title**	**Project end date**
SIMUTOOL	Integrated design and novel tooling and process optimisation of microwave processing of composites	2019-02-28
OPTIMISED	Operational Planning Tool Interfacing Manufacturing Integrated Simulations with Empirical Data	2018-10-31
MOTOR	Multi-ObjecTive design Optimization of fluid eneRgy machines	2018-08-31
MC-SUITE	ICT Powered Machining Software Suite	2018-09-30
MAYA	Multi-disciplinArY integrated simulAtion and forecasting tools, empowered by digital continuity and	2018-09-30

	continuous real-world synchronization, towards reduced time to production and optimization	
IMPROVE	Innovative Modeling Approaches for Production Systems to raise validatable efficiency	2018-08-31
CAxMan	Computer Aided Technologies for Additive Manufacturing	2018-08-31

2.1.6 FoF9 –2015: ICT Innovation for Manufacturing SMEs (I4MS)

Relevance of projects to IoT to be identified. Extract from call topic:

- HPC Cloud-based modelling, simulation and analytics services for modelling multiple interconnected phenomena; **for integrating novel mobile interfaces for data management and decision support; for achieving real-time response** and addressing comprehensively security and privacy issues at all levels.
- **Integration of Cyber-Physical-System modules in manufacturing processes and process chains** (application or assessment experiments) to increase sophistication and automation in production SMEs and to create novel value added services linked to process surveillance and maintenance.

In this last topic, the **BEinCPPS** proposal (Business Experiments in Cyber Physical Production Systems, coordinated by Politecnico di Milano) has been admitted to the Grant Preparation Phase and will be soon start its activities (1 November 2015) to support the adoption of CPPS by manufacturing SMEs (as I4MS Phase II project). From an architectural viewpoint, BEinCPPS promotes a federation of existing state-of-the-art IT platforms covering the Machine level (covered by CPS research and ARTEMIS ECSEL innovation); the Factory level and its information systems (covered by FITMAN platforms); the Cloud level and its services (covered by FIWARE architecture and enablers).

Open Calls will be launched in Spring 2016 for IT application providers on top of the above mentioned three levels architecture. From an experimentation view point, 5 champions have been selected in 5 Vanguard regions in Europe (Lombardia, Euskadi, Rhone Alpes, Norte, Baden Wuerttemberg) to be the catalyst for CPPS-driven innovation among the SMEs located in their respective regions. Open Calls will be launched in Fall 2016 for Manufacturing SMEs willing to replicate the experience of the 5 champions in different sectors, domains and regions. A Third Open Call is instead devoted to extend the ecosystem of Competence Centers CCs in not-I4MS regions: some of these additional CCs will be assigned to BEinCPPS.

2.2 National / Regional Initiatives similar to the FoF PPP

At national level, there are many initiatives that relate to the Factories of the Future PPP, such as for example:

- Germany: Industrie 4.0 (+ several regional initiatives)

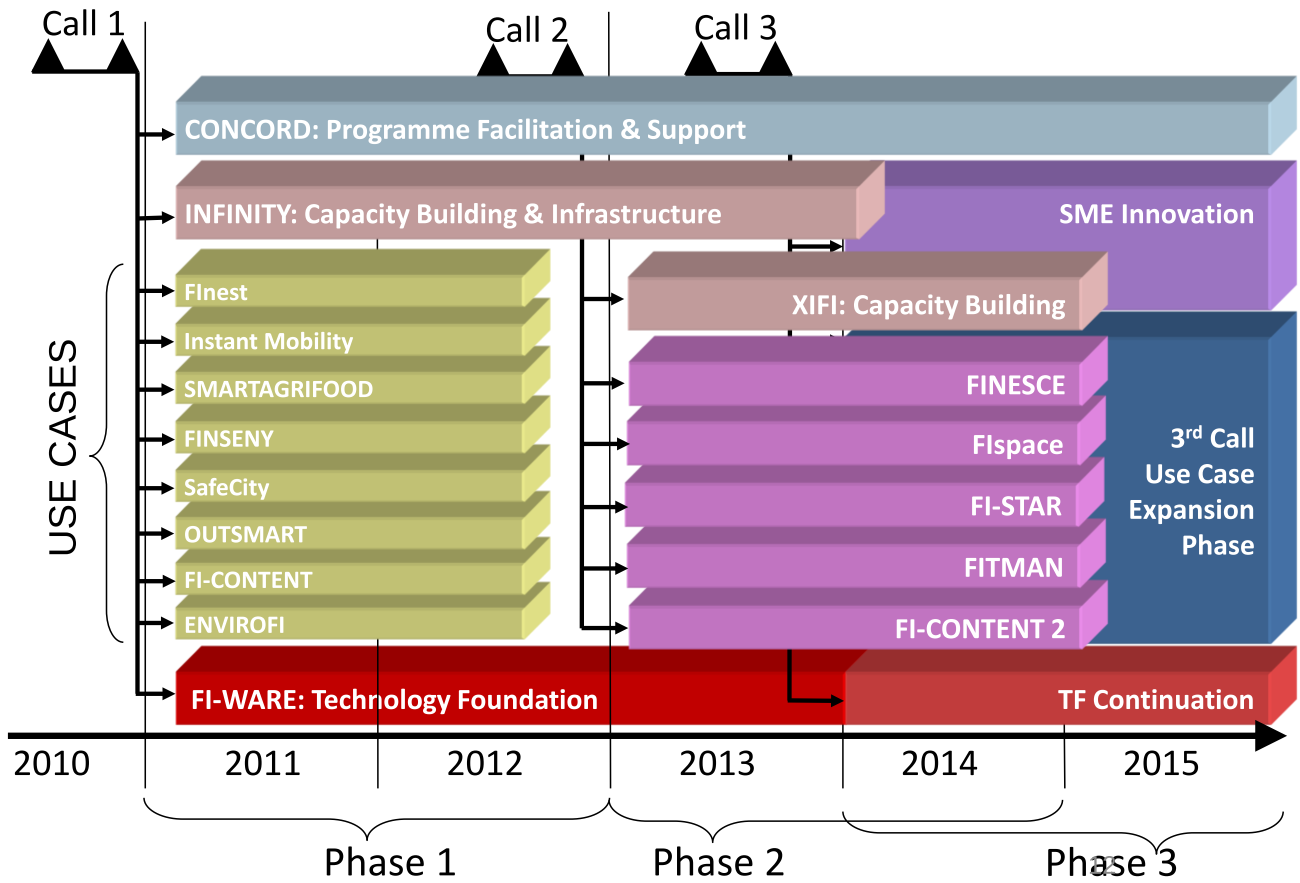
- UK: High Value Manufacturing (Catapult the MTC)
- Italy: Fabbrica Intelligente (and Lombardia)
- Spain: initiatives Basque and Catalunya
- Netherlands: Smart Industry
- Portugal: Produtech
- France: Usine du Future
- Belgium: Made Different, Flanders Make

Following document provides an overview of national level activities that relate to the Factories of the Future PPP:
Executive Summary and Final Report of the workshop on Innovation in Digital Manufacturing organised by DG Connect in cooperation with EFFRA (20-21 January 2015): https://ec.europa.eu/digital-agenda/en/news/european-co-operation-innovation-digital-manufacturing

2.3 FI PPP

2.3.1 FIWARE IOT technologies

FIWARE (www.fiware.org) is the initiative developing and exploiting the results achieved by the several projects of the FI PPP. A graphical scheme of the FI PPP three Phases is depicted here below, with the Technology Foundation projects running in the red bar, the capacity Building projects in the pink bar and the Use Cases projects in the purple bars along Phase II.

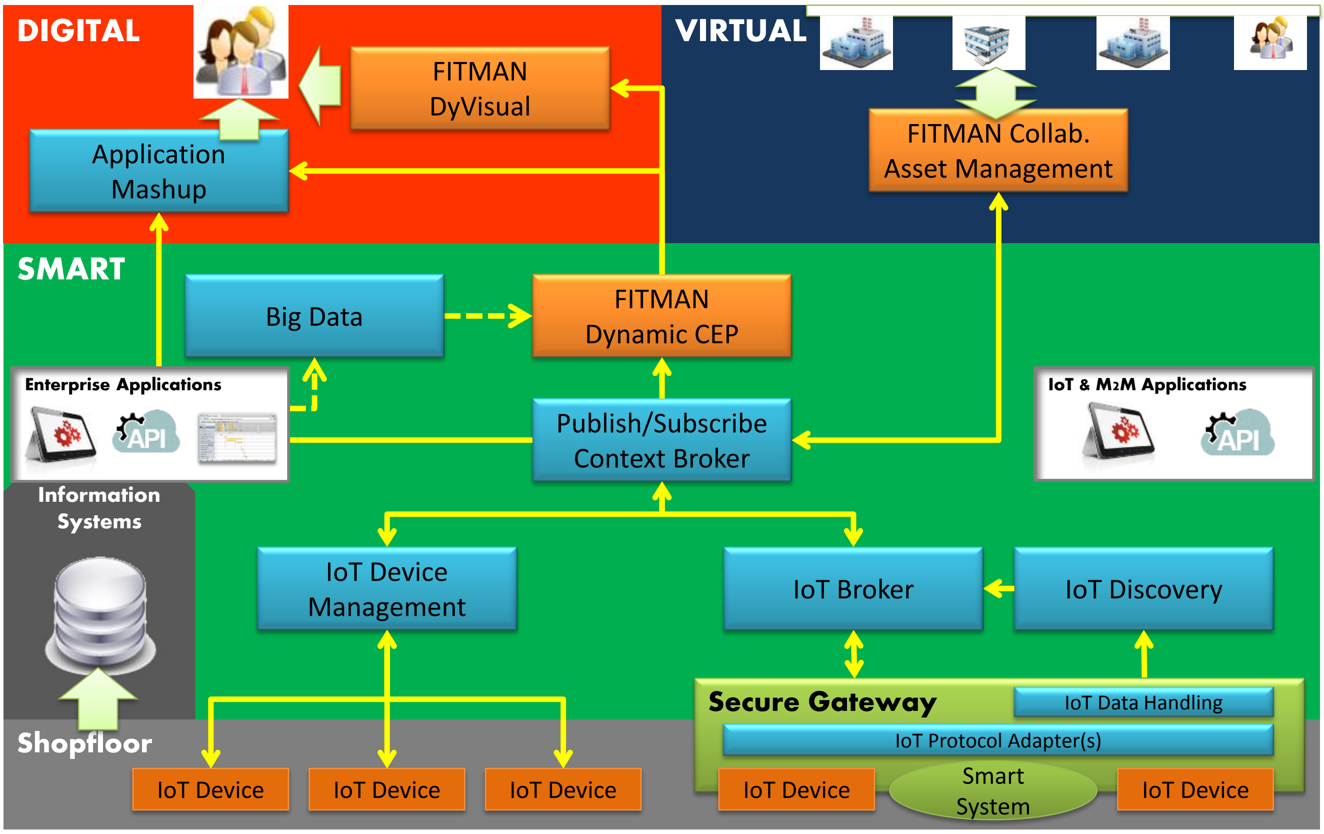


In the FIWARE catalogue (http://catalogue.fiware.org/) almost 40 open source software components are supported for developers as elementary Lego Blocks to create their own applications in several technological chapters and application domains. In particular, the catalogue's chapter "*Internet of Things Services Enablement*" include 5 open source components (protocol adapter, device management, IoT Discovery, IoT Broker and Data Handling CEP) which could be considered as the common basis for any IoT-oriented architecture and application. A typical way to combine them is reported in https://www.fiware.org/devguides/connection-to-the-internet-of-things/ under a reference architecture http://forge.fiware.org/plugins/mediawiki/wiki/fiware/index.php/Internet_of_Things_%28IoT%29_Services_Enablement_Architecture which is based on the OMA NGSI standard http://technical.openmobilealliance.org/Technical/technical-information/release-program/current-releases/ngsi-v1-0.

2.3.2 FITMAN

As introduced above, FITMAN (www.fitman-fi.eu) is the FI PPP Phase II project aiming at developing use case trials in several manufacturing domains which will test and experiment the FIWARE technologies enriched by some manufacturing specific enablers. The current FITMAN

offer includes 15 specific enablers complementing the generic enablers offered by FIWARE (see FITMAN catalogue http://catalogue.fitman.atosresearch.eu/), three domain specific reference architectures (for Smart Digital and Virtual Factories of the Future) and ten trial specific platforms covering more than 50 business processes in Manufacturing.
Additionally, FITMAN developed a conceptual model for an IOT 4 Manufacturing platform, integrating together aspects of Smart-Digital-Virtual platforms, which will be tested and adopted in one of the ten FITMAN trial industrial sites. In particular, the FITMAN IOT Platform synthetic view is reported here below.



2.4 SoS and CPS

In the DG CNECT A3 Unit and in particular after the H2020 ICT1 2014 call “Smart Cyber Physical Systems” (which will be replicated in 2016 ICT1), several projects have been funded and many of them have direct links with Smart Manufacturing domain. In particular, we distinguish 3 roadmapping / consensus building CSAs (plus a fourth financed in a previous call about CPSoS), 8 RIA and 4 IA which will be briefly listed in the following tables.

Project Acronym	Title	Website
ROAD2CPS	Strategic action for future CPS through roadmaps, impact multiplication and constituency building	http://www.road2cps.eu/
TAMS4CPS	Trans-Atlantic Modelling and Simulation For Cyber-Physical Systems	http://www.tams4cps.eu/
CPS-SUMMIT	Towards Cyber-Physical Systems Engineering Tools Interoperability Standardisation	
CPSoS	Cyber-Physical Systems of Systems: Towards a European Roadmap on Research and Innovation in Engineering and Management of Cyber-Physical Systems of Systems	http://www.cpsos.eu/

Project Acronym	Title	Website
TAPPS	Trusted Apps for open CPS	
SAFURE	SAFety and secURity by design for interconnected mixed-critical cyber-physical systems	http://www.safure.eu/
UnCoVerCPS	Unifying Control and Verification of Cyber-Physical Systems	
U-TEST	Testing Cyber-Physical Systems under Uncertainty: Systematic, Extensible, and Configurable Model-based and Search-based Testing Methodologies	http://www.u-test.eu/
AXIOM	Agile, eXtensible, fast I/O Module for the cyber-physical era	http://www.axiom-project.eu/
IMMORTAL	Integrated Modelling, Fault Management, Verification and Reliable Design Environment for Cyber-Physical Systems	
INTO-CPS	INtegrated TOol chain for model-based design of CPSs	http://into-cps.au.dk/
COSSIM	A Novel, Comprehensible, Ultra-Fast, Security-Aware CPS Simulator	

Project Acronym	Title	Website
EUROCPS	European Network of competencies and platforms for Enabling SME from any sector building Innovative CPS products to sustain demand for European manufacturing	https://www.eurocps.org/
CPSELABS	CPS Engineering Labs - expediting and accelerating the realization of cyber-physical systems	http://www.cpse-labs.eu/
EOT	Eyes of Things	http://eyesofthings.eu/
CP-SETIS	Towards Cyber-Physical Systems Engineering Tools Interoperability Standardisation	http://cp-setis.eu/

Finally the application domains covered by the RIA are reported in the picture below.

	Aero-space	Auto-motive	Tele-communication	Health	Surveillance	Smart Buil-dings	Logi-stics	Smart grids	Manufacturing	Rail way	Agriculture	Visual search
SAFURE		x	x									
COSSIM								x				x
Tapps		x		x								
IMMORTAL	x											
AXIOM					x	x						
UnCoVer CPS		x						x	x			
U-Test				x			x					
Into CPS		x				x				x	x	

2.5 ARTEMIS and ECSEL

Many activities of ARTEMIS in FP7 and ECSEL in Horizon 2020 produced projects on IoT and Manufacturing. Following were the most relevant:

- CRYSTAL
- EMC2
- CYPHERS
- ARROWHEAD
- MANTIS
- SOFIA

2.6 The IERC Cluster and the Digital Business Innovation Community

The following R&I projects belonging to the "Sensing Enterprise" cluster have been reported. Most of these have a horizontal approach, hence they also relate to manufacturing enterprises.

Project Acronym	Title, Mission	Project end date	Website
OSMOSE	OSMOsis applications for the Sensing Enterprise. The project aims at developing a reference architecture, a middleware and a navigation environment for linking together IoT Real Digital and Virtual worlds for sensing and liquid Enterprises.	2016-08-31	http://www.osmose-project.eu/
PROASENSE	The Proactive Sensing Enterprise. The project aims at paving the way for an efficient transmission from Sensing into Proactive enterprises by exploiting the power of big enterprise data (through sensing the whole business ecosystem), extracting the actionable meaning from data (through advanced big data analytics) and increasing the strategic value of data analysis for the decision making	2016-10-31	http://www.proasense.eu/
INTERACT	Interactive Manual Assembly Operations for the Human-Centered Workplaces of the Future. The project aims at utilizing workers' knowledge on executing manual assembly tasks and including it in the digital tools used to support design, verification, validation,	2016-09-30	http://www.interact-fp7.eu/

	modification and continuous improvement of human-centred, flexible assembly workplaces.		
CaaS	Capability as a Service in digital enterprise. The project aims at facilitating configuration of business services and development of executable software to monitor the fitness of purpose of these services to evolving business contexts and where necessary to adjust these services according to the context.	2016-08-31	http://caas-project.eu/
SERAMIS	Sensor-Enabled Real-World Awareness for Management Information Systems. The project aims at covering the entire causal chain from the initial investment in an RFID data collection infrastructure to the impact of data processing on firm performance.	2017-03-31	http://seramis-project.eu/
FutureEnterprise	Road mapping, Research Coordination and Policy activities supporting Future Internet-based Enterprise Innovation	2016-03-31	http://www.futureenterprise.eu/
TELLME	Technology Enhanced Learning Livinglabs for Manufacturing Environment. The project aims at developing a reference methodology and a set of VR/AR-based IT platforms for up- and re-skilling of blue collar workers in production and maintenance of complex products	2015-09-30	http://www.tellme-ip.eu/

2.7 Format for a more systematic analysis of existing pilot activities

A format has been established for a more systematic analysis of ongoing pilots or relevant initiatives in relation to the use cases they address and the technologies they deploy or develop.

Use cases																	
Link with end-users			Economic sustainability				Social sustainability			Environmental sustainability of manufacturing							
Manufacturing the products of the future	Close-loop management from to design-to-use	Product-Service optimisation	Addressing economic performance across the supply chain	Realising reconfigurable, adaptive and evolving factories capable of small - scale production	High - performance production, combining flexibility, productivity, precision and zero - defect while rem	Closing the loop with the customer	Increase human achievements in future European manufacturing systems	Creating sustainable, safe and attractive workplaces for Europe 2020	Creating sustainable care and responsibility for employees and citizens in global supply chains	Environmental sustainability of manufacturing	Reducing the consumption of energy, while increasing the usage of renewable energy	Reducing the consumption of water and other process resources	Near - to - zero emissions, including noise and vibrations, in manufact	Optimising the exploitation of materials in manufacturin	Co - evolution of products–processes–produ	industrial symbiosis' with minimum need of	Other - please specify

IoT Technologies																	
Smart Sensors and Networks				Smart Systems			Data management							Privacy and security			
Sensors and Sensors Networks (incl. energy harvesting swarms)	Identification Technologies (incl. RFID)	Smart Networks and Protocols (incl IPv6)	Smart Mobile and Protocols (incl. 5G)	Microsystems and Components (incl. ECSEL)	Embedded Systems and Systems of Systems	Cyber-Physical Systems	RealTime Event and Data Management (incl. IOT Broker)	Semantic Interoperability	Cloud Computing	Knowledge Management and Business Intelligence	Big Data Analytics	Distributed Decision Making (incl. Multi Agent Systems)	Learning and Educational Platforms	Authentication / Authorisation (incl. Identity managem	Data protection and Privacy presen	Security by Design	Cyberse

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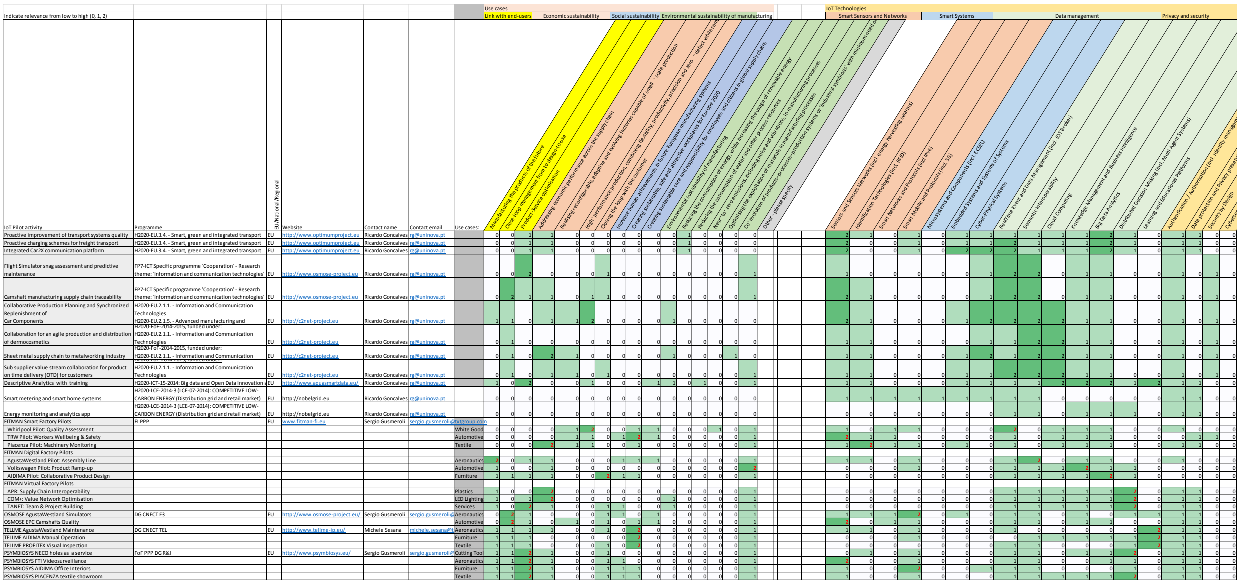
ALLIANCE FOR INTERNET OF THINGS INNOVATION



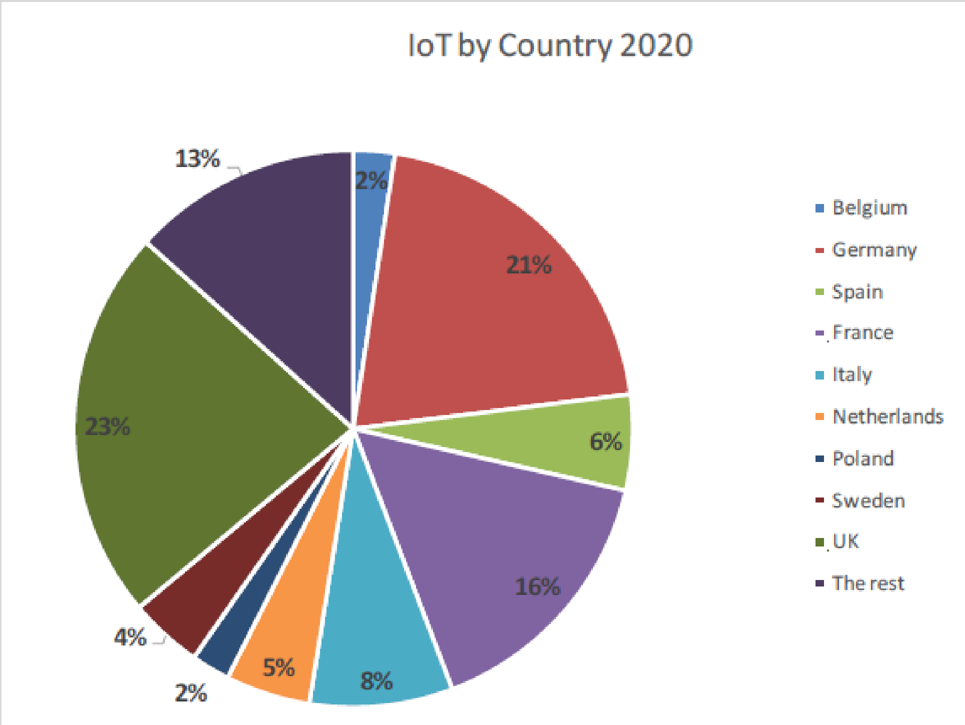
2.8 Activities carrying out market analysis and studies in the area of IoT for Manufacturing Ecosystem

2.8.1 SMART number 2013/0037: Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination

The study (conducted by IDC Italia and TXT e-Solutions) investigates the conditions enabling the European industry to actively participate in the development of the emerging IoT and Cloud combined ecosystems. The report sets out recommendations to meet Europe’s IoT-related research & innovation challenges and support or accelerate IoT adoption across a number of use cases and lead markets in Europe.

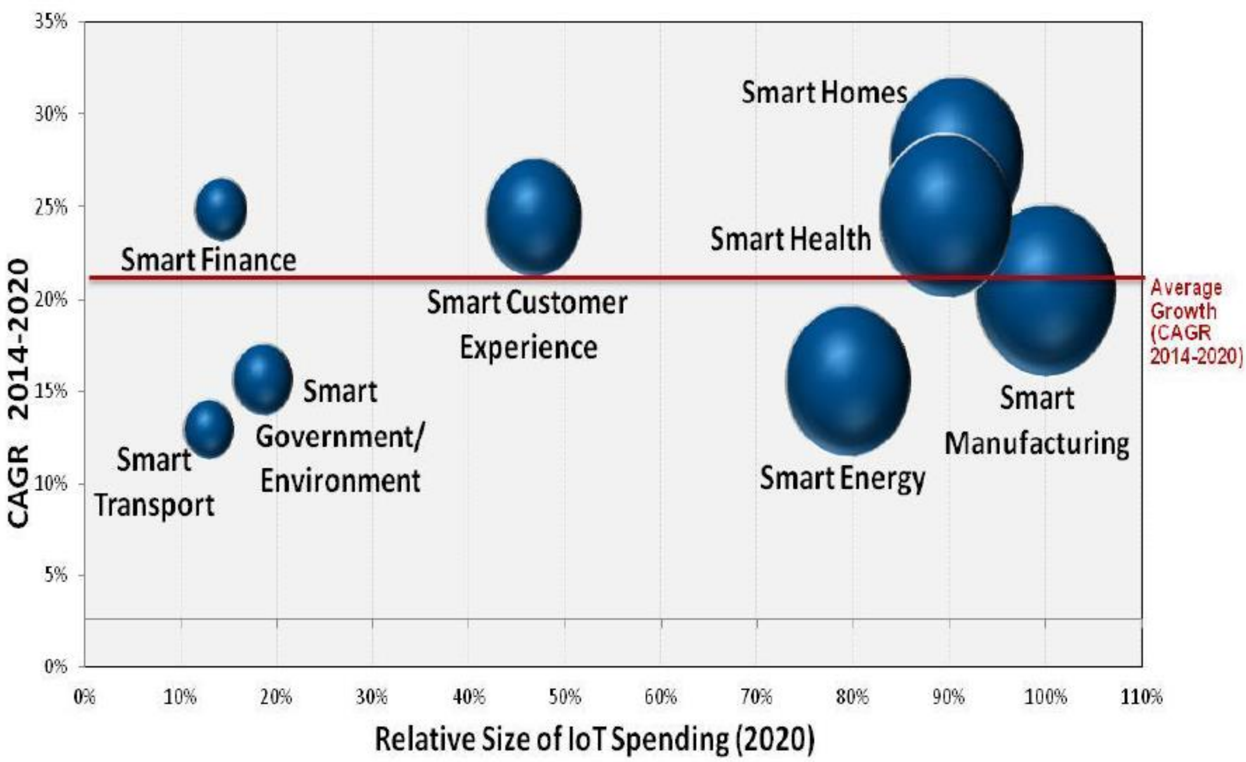
Inside the final report of the study (openly available in [http://ec.europa.eu/digital-agenda/en/news/definition-research-and-innovation-policy-leveraging-cloud-computing-and-iot-combination smart manufacturing is indicated as one of the most promising sectors for a full and profitable adoption of IOT (see two pictures hereinafter).](http://ec.europa.eu/digital-agenda/en/news/definition-research-and-innovation-policy-leveraging-cloud-computing-and-iot-combination)

Figure 6 IoT Market Size and Forecast: Baseline Scenario by Country (2020; %)



Source: IDC 2014

Figure 9: Smart Environments by IoT Spending Size and Growth



Source IDC 2014

2.8.2 Benchmark Study for Large Scale Pilots in the area of Internet of Things

A study (conducted by Price Waterhouse Coopers EU Services) identifies and benchmarks possible use cases for future demo activities in the domain of the Internet of Things (IoT). Following areas relate to manufacturing.

WORKER SAFETY: IoT use cases aiming to increase worker safety in factories and on construction yards by adding sensors to industrial equipment (e.g. forklifts, cranes, bulldozers, conveyor belts) and personal safety equipment (e.g. wearables, helmets, clothing). The use cases would enable to locate workers, notify co-workers of possible dangerous situations, monitor vital health signs (e.g. temperature and oxygen levels for firefighters), monitoring factory hall parameters, avoiding collisions, emergency stops of machinery.

SMART MANUFACTURING: CUSTOMISATION: IoT use cases that enable the production of customised outputs. Such production systems would combine the low unit costs of mass production processes with the flexibility of individual customisation.

AUTOMATED MANUFACTURING: IoT use cases enabling the connection of machinery and systems within the plant so that manufacturers can automate workflows to maintain and optimise production systems without human intervention. This would include among others the following use cases:

- Machine-to-machine communication and embedded intelligence;
- Intelligent connected tools for operators;
- Software to monitor how equipment is performing and automatically make corrections;
- Smart tools that monitor and guide operator work flows;
- Automated pick-up and delivery in large inventories.

- SMART FACTORY: IoT use cases allowing to collect real-time factory data which, in turn, facilitates management decisions and aiming to minimise equipment failures by means of collecting actual performance data and monitoring equipment health.

- SMART MANUFACTURING: IoT use cases equipping manufactured items with reusable Radio-Frequency Identification (RFID) smart tags and/or sensors connecting the production line to the systems of other actors in the supply chain, making the entire lifecycle of individual manufactured items visible so that all parties can understand interdependencies, the flow of materials, and manufacturing cycle times. This use cases enables among others:
    - Decentralised manufacturing hubs;
    - Consistent tracking of goods throughout the distribution chain;
    - Linking real-time distribution data with real-time production data;

- Pervasive visibility: closing the ‘black spots’ or visibility gaps across a supply chain using RFID chips;
- Proactive replenishment of inventory;
- Reduce packaging by publishing product specifications, in reusable RFID tags; Protect against counterfeiting with secured RFID tags;
- Locate products on warehouse shelves; Automated inventory;
- Automated checkout in distribution centres;
- Automated waste disposal; and Automated waste sorting facilities based on information in reusable RFID tags.

3 Future calls / call topics in the pipeline covering IoT and manufacturing

3.1 Horizon 2020 – WP16-17

Within the Factories of the Future PPP, the FoF 2016-2017 FoF calls were published. The public EU funding available is €278 Million, submission deadline is 21 January 2016. In many of these calls IoT technology can have its place:
http://www.effra.eu/index.php?option=com_content&view=article&id=697:278-million-available-for-manufacturing-innovation&catid=45&Itemid=260

This concerns in particular call FoF 11, with an envelope of 53 million Euros.
http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2365-fof-11-2016.html
Demonstration project of some € 4-8 million, in justified cases even beyond, will be funded. Background information on this FoF 11 call are available here:
https://ec.europa.eu/digital-agenda/en/news/platforms-connected-factories-future

Other Horizon 2020 calls that address IoT and manufacturing are:

- ICT-15-2016-2017: Big Data PPP: Large Scale Pilot actions in sectors best benefitting from data-driven innovation
- ICT-01-2016: Smart Cyber-Physical Systems
- ICT-03-2016: SSI - Smart System Integration
- ICT-04-2017: Smart Anything Everywhere Initiative
- FOF-12-2017: ICT Innovation for Manufacturing SMEs (I4MS)
- EUB-02-2017 : IoT Pilots (EU-Brazil cooperation, with manufacturing focus)
- EUJ-02-2016: IoT/Cloud/Big Data platforms in social application contexts

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