CREATE-IoT

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CROSS FERTILISATION THROUGH ALIGNMENT, SYNCHRONISATION AND EXCHANGES FOR IoT

H2020 – CREATE-IoT Project

Deliverable 01.01

IoT FA strategy and coordination plan

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Summary					
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Editor	O. Vermesan (SINTEF)				
DoW	This deliverable summarizes part of the work carried out in task T01.01 (IoT Focus Area coordination and road mapping), and provides the framework for collaboration and exchange of information among various IoT activities, and focuses on the delivery of solutions of a global/common nature and scope.				
Comments					

Document history			
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1. EXECUTIVE SUMMARY

Publishable summary

Internet of Things (IoT) is enabling, driving and accelerating digital transformation, business creation/change opportunities and improvements by the ways the things are connected, data is analysed and products, services and virtual experiences are created across various areas of the society.

The technological developments are moving towards integration and outcomes with digital transformation technologies converging and meeting each other, depending on use case, scope, application etc.

Consumer, business and the Industrial IoT are converging and the focus is put on how enabling technologies are affecting processes, people, benefits, outcomes and real-life opportunities in the context of the hyper-connected society with the aim of leveraging connected knowledge at scale for optimization, innovation and human purpose.

In this context, this document provides the framework for collaboration and exchange of information among IoT European Large-Scale Pilots Programme projects and various IoT activities in Europe to support the delivery of IoT solutions of a global/common nature and scope. The document analyses the global IoT ecosystem and describe the exchange of information on best practices and approaches for object connectivity, protocols, data formats, privacy, security, open APIs among various IoT Focus Area (IoT-FA) activities and stakeholders under the activity groups in which the partners from the IoT large-scale pilot projects are involved. Each covered topic in this document is approached from the perspective of the delivery of solutions of a global/common nature and scope with respect to all involved stakeholders.

The document offers the description of the process of strategic planning for the IoT-FA based on the defined objectives, the internal and external factors. The document addresses the collaboration, cooperation, and coordination among IoT European Large-Scale Pilots Programme projects and various IoT activities in Europe based on its integration into the strategic planning process. Collaboration provides an opportunity to share knowledge, experience and skills among the IoT European Large-Scale Pilots Programme projects to modify goals and contribute to the development of IoT FA. The cooperation mechanism introduced includes partnering among the large-scale pilots in activity groups (AGs) in terms of resources, capabilities, and competencies in pursuit of mutual interests for the advancement of common goals for the IoT European Large-Scale Pilots Programme. This combination of efforts in generation of knowledge, exchanging, co-creation, dissemination, communication, and sharing of best practices is a form of joint benefit, very fundamental to success for the IoT-FA.

Non-publishable information

This document is public.

2. INTRODUCTION

2.1 Purpose and target group

The aim of IoT-FA strategy and coordination plan is to harmonize and correlate the IoT activities of IoT European funded projects and related IoT activities through mapping corresponding developments and consolidate them together with the pilots at IoT-FA level, and include where appropriate results from other relevant activities in various industrial domains. The objectives are to stimulate collaboration between IoT initiatives, foster the take up of IoT in Europe and support the development and growth of IoT ecosystems based on open technologies and platforms. This requires alignment and synchronization on strategic and operational terms through frequent, multi-directional exchanges between the various activities under the IoT-FA. It addresses cross fertilisation of the various IoT large-scale pilot projects and other IoT initiatives for technological and validation issues of common interest across the various application domains and use cases.

2.2 Contributions of partners

This delivery is one of six deliveries from task T01.01 (IoT Focus Area coordination and road mapping), and provides the framework for collaboration and exchange of information among various IoT activities, and focuses on the delivery of solutions of a global/common nature and scope. The description below explains the partner contributions in task T01.01.

SINTEF is the task leader (T01.01) and the deliverable responsible. SINTEF coordinated the activities and developed, with the partners involved in the IoT FA initiatives, a plan that matches short-term and long-term goals of the IoT FA with IoT technology solutions, deployment, applications and policy issues to help meet these goals. The work ensured that the IoT roadmap in the consecutive deliverable D01.02, helps reach a consensus about a set of IoT FA stakeholders' needs and the technologies, policy issues required to satisfy those needs, provides a mechanism to help forecast IoT technology, deployments and policy trends developments, and provides a framework to help plan and coordinate IoT technology. Application, policy developments in Europe, with a global perspective. Worked for the alignment and synchronisation of the activities with the work of the AIOTI, IoT-EPI and IoT LSPs for developing a sound coherent strategy for open exchanges and collaboration between the various activities of the FA. The activities included the promotion for sharing of conclusions and road mapping with similar activities in countries and regions outside Europe.

ATOS worked on the analysis of relevant activities and stakeholders involved in the IoT, linking their area of work to the business models they are adopting. This information is processed to identify best practices based on research done and ATOS experiences in ongoing and past projects in the IoT domain.

PHILIPS contributed to the next stages of IoT deployment including through pre-commercial or joint public procurement. Based on their work in the LSP's and company work they shared their insights on what the next step are on this. Needed is a broader market assessment, stakeholders interviewing and organizing workshops to come to a validated road mapping in the consecutive deliverable D01.02. This are aligned on national, European and regions outside Europe. Both technical and business experts have participated and the work is in full alignment with their AIOTI work.

IDC worked on necessary alignment with the existing and most up-to-date methodologies currently in use to design, test and validate KPIs of impact measurement across similar

endeavours and, more generally, with respect to the present and future development of IoT markets and ecosystems in Europe and worldwide. The task began with a rigorous and comprehensive stock-taking of the impact assessment KPI methodologies currently in place and adopted in existing IoT ecosystems in Europe, North America and Asia-Pacific region and provided an analysis of their key strengths and weaknesses. Subsequently, a restricted number of methodologies have been selected and submitted to peer IDC analysts not directly involved in the consortium and to the other member of the consortium for further analysis and validation. Finally, the most appropriate methodology framework has been chosen and adequately adjusted to respond to the specific needs and requirements of the IoT ecosystems under consideration in the present project. Worked on the creation of a conceptual framework for the collection of pertinent data on IoT activities and additional use cases currently ongoing in those European countries not covered by the present consortium members. A similar activity has been directed at additional IoT initiatives in other mature and emerging markets outside Europe.

IDATE provided market analysis of the global IoT ecosystem. This includes activities of analysis of the FA (stakeholders' interviews, business models analysis) as well as analysis of the global IoT market (market assessment in the various vertical, market sizing, competition analyses). IDATE are directly involved in the production of the roadmap in the consecutive deliverable D01.02, bringing together the technical and non-technical inputs and directing the edition process, contribute to the roadmap by analysis of the market forces (demand-pull), the technology readiness (technology push), and the future needs in term of scientific research, public policies, and industry activities.

BLU focused on analysing planned start-up, developer and SME involvement, procedures, including publication channel for calls to ensure that the broader IoT community is aware of them and able to participate, selection criteria and process; monitoring mechanisms.

GRAD provided a liaison with the AIOTI vertical WGs, coordinated their contributions to a roadmap (in the consecutive deliverable D01.02) for the wide adoption of IoT in the corresponding sectors, at a European level. GRAD also provided links with the task T02.02 for integrating the methodologies, best practices and business models aspects learnt from the LSPs in the roadmap.

NUIG worked on addressing the linkage between AIOTI WGs and the IERC community projects by providing strategic and operational support to the direction of the IoT community and by supporting the coordinating to define technical and operational priorities that can be transformed in the IoT road mapping in the consecutive deliverable D01.02. The main contribution has been to guide in the direction of semantic interoperability vision and the definition and uptake of semantic methodologies for the IoT, helped on bridging current ICT 30 projects activity with the LSP, and in general continued building community through the contribution to support IoT focus activities.

MI contributed to the task by leveraging on its active engagement in the IoT community, included through the IoT Forum, the IoT Lab and SDOs activities, included at the ITU ad IEEE. MI supported the global road mapping, in the consecutive deliverable D01.02, with a focus on international cooperation.

AS supported the global road mapping activities with a focus on IoT and privacy, hence form the basis of the consecutive deliverable D01.02.

2.3 Relations to other activities in the project

The IoT-FA strategy and coordination plan is part of the activities focusing on the support of the IoT-FA through development of a sound coherent strategy for open exchanges and collaboration between the various activities of the FA. The principles of coordination are implemented incrementally by considering various activities of the FA, the stakeholders that are involved and

the business models proposed by the various IoT ecosystems. The activities are aligned with the coordination of AIOTI and the collaboration with the IoT-EPI that allow developing a common strategy on IoT at European level. This document highlights the strategy and coordination plan that provides the framework for collaboration and exchange of information among various IoT activities, and focuses on the delivery of solutions of a global/common nature and scope. The solutions intend to address identified gaps in the way the IoT initiatives manage information and knowledge across IoT projects, pilots, application domains, as well as supporting corrective measures for interventions and alignment. The implementation of the coordination plan is done through eight activity groups that provide the adequate support, information management and common coordination capacity in coordinating the IoT FA by using innovative methods and approaches that can respond to developing external trends and better enable the IoT initiatives and stakeholders to respond to the needs of the end-users, the market development and the society challenges. These activity groups create mechanisms to:

- Coordinate the exchange of information on best practices and approaches for object connectivity, protocols, data formats, privacy, security, open APIs among various IoT-FA activities and stakeholders;
- Support the development of common methodologies and KPIs for design, testing and validation and for success and impact measurement across various use cases and application domains;
- Promote and create ways for sharing of conclusions and road mapping at European level, with activities at the national level and similar activities in countries and regions outside Europe.
- Preparation for the next stages of IoT deployment including through pre-commercial or joint public procurement.
- Efficient information sharing across IoT-FA stakeholders for horizontal common interests' issues.

3. IoT FA Activities and Stakeholders

3.1 Internet of Things

The Internet of Things (IoT) represents the next Industrial Revolution, the next Internet development and the future of the way businesses, governments, and consumers interact with the physical world by using connectivity, security, data storage, system integration, device hardware, and IoT application development.

IoT is transforming the everyday physical objects in the surrounding environment into ecosystems of information that enrich people's lives. IoT is bridging the gap between the physical and the digital or virtual worlds, facilitating the convergence of advances in miniaturization, wireless connectivity, increased data-storage capacity and batteries. IoT is a set of key enabling technologies for digital businesses and one of the main drivers contributing to transforming the Internet and improving decision-making capacity via its augmented intelligence. People will engage with IoT applications using all their senses: touch and feel, sight, sound, smell and taste, individually or in combination. Success in developing value-added capabilities around IoT requires a broad approach that includes expertise in sensing/actuating, connectivity, edge computing, machine learning, networked systems, human-computer interaction, security and privacy. IoT technologies are deployed in different sectors, from agriculture in rural areas to health and wellness, smart home and smart-X applications in cities [2].

3.1.1 Activities and stakeholders

In general terms, the IoT stakeholders are defined as any party that is committed, technically financially or otherwise, to an IoT ecosystem or IoT technology and is therefore affected by its performance.

IoT technology stakeholders can be represented by a company, a group or a person that has interest or concern in IoT technology development and is part of the IoT technology value chain.

Stakeholders can affect or be affected by the IoT technology trends, development, research, innovation and policies. Key stakeholders are electronic component manufacturers (sensor/actuators/MEMS, semiconductor), telecom, software, cloud or service providers, and the community from which the business draws its resources.

IoT application stakeholders can be represented by end users, customers, suppliers, communities, and shareholders of the companies that use that IoT application. In IoT applications across various industrial verticals there is a need to consider a broader group that includes local city governments, media, non-governmental organisations (NGOs), citizens, etc.

In the IoT technologies and applications context, there are numerous "stakeholders" in various IoT ecosystems supported by open technologies and platforms. Product and service companies engage with these stakeholders to complete the layers that lead to value creation and capture such as technology, hardware components, software, services, experiences, IP rights, resources, and other things that provide a competitive advantage. App, hardware, software and services developers create business value through innovation, and the business ecosystem captures value during the in-market phase.

This report addresses the European IoT ecosystem from a global perspective and focuses on the IoT ecosystems created by the IoT European Large-Scale Pilots Programme, the Internet of Things European Platforms Initiative (IoT-EPI) and other relevant initiatives at EU, Member

States and international levels. In this context, it is important to analyse and understand the incentive for each stakeholder, to encourage sustainability of value creation within a stakeholder value network. The aim is to provide the support needed so the IoT ecosystem delivers value to end-users, and in return, each player in the ecosystem benefits from their involvement. Today, many technology providers attached the IoT acronym to their names, resulting in a proliferation of companies promoting their IoT platforms, IoT applications, IoT solutions and more.

3.1.2 Ecosystem complexity

The IoT ecosystem is a system formed by the interaction of a community of companies/stakeholders with their technological and business environment. The IoT European ecosystems were created on one side by the interaction of a community of companies/stakeholders providing various enabling IoT technologies, services and infrastructure working around IoT platforms, in the case of IoT-EPI projects, or working to address the challenges into an application domain as for the case of IoT European Large-Scale Pilots Programme projects. Both these IoT ecosystems are defined by core components and complemented by applications made by autonomous companies in the periphery creating of an environment considered in relation to each other as a unit.

These types of IoT ecosystems form the fundament for the development of strong European IoT community and support the stakeholders' mobilization that creates a sustainable strong development of business and society in Europe.

3.2 Internet of Things Focus Area

Internet of Things - Focus Area (IoT-FA) aim is to foster the take up of IoT in Europe and to enable the emergence of IoT ecosystems supported by open technologies and platforms. This is addressed through a complementary set of activities structured around IoT Large-Scale Pilots.

The pilots make use of the rich portfolio of technologies and tools so far developed and demonstrated in reduced and controlled environments and extend them to real-life use case scenarios with the goal of validating advanced IoT solutions across complete value chains with actual users and proving its enormous socio-economic potential. Coordination among the pilots and other IoT activities ensures the interplay of the various elements of the IoT-FA and liaise with relevant initiatives at EU, Member States and international levels.

Mission - IoT-FA unites excellence in research, innovation, development, and deployment to create a user-centred IoT community.

Vision - IoT-FA aims to foster the take up of IoT in Europe and to enable the emergence of IoT ecosystems supported by open technologies and platforms through IoT research and innovation programs grounded in novel, enhanced and secured IoT technologies, services and applications; engaging stakeholders in IoT research and deployment experiences, within and beyond the labs and test facilities; nurturing the development of IoT best practices to contribute to regional, European and global communities; building a heterogeneous, inclusive and innovative IoT development and users community; and offering sustainable, standardised, interoperable IoT solutions for different use cases in different industrial sectors and across the sectors.

Strategic Plan 2017 - To support its mission and achieve its vision, the IoT-FA and the IoT European Large-Scale Pilots Programme are pursuing several goals in the next three years. Each goal will be implemented through a variety of initiatives, which are illustrated below.

Collaboration, cooperation, and coordination - with the goal to promote a collaboration cooperation, and coordination environment that facilitates excellence in research, and creative activity to support the IoT ecosystems based on open technologies and platforms through

partnering among the large-scale pilot projects in activity groups (AGs) in terms of resources, capabilities, and competencies.

- Establishment eight activity groups as a mechanism that that implements the collaboration cooperation, and coordination and supports the IoT ecosystems and the exchange of best practices.
- Expand and liaise with relevant initiatives at EU, Member States and international levels.
- Mapping of pilot architecture approaches with validated IoT reference architectures such as IoT-A enabling interoperability across use cases;
- Contribution to clustering their results of horizontal nature (interoperability approach, standards, security and privacy approaches, business validation and sustainability, methodologies, metrics, etc.).
- Connect with other initiatives including contractual Public-Private-Partnerships (e.g. Big Data, Factories of the Future, 5G-infrastructure), Joint Technology Initiatives (e.g. ECSEL), European Innovation Partnerships (e.g. on Smart Cities), and other Focus Areas (e.g. on Autonomous transport).

End users engagement - with the goal to engage IoT end users as active participants in IoT developments and deployments by promoting opportunities in use cases and application scenarios with end users' learning and experience outcomes.

- Provide development opportunities for stakeholders and particular end users to use the IoT best practices associated with the IoT use cases and implementation scenarios in the various IoT pilot sites.
- Design activities to enhance advising and mentoring programs for IoT end users and SMEs.
- Increase participation of IoT developers, end users, regional stakeholders in IoT pilot activities.

Regional, European and Global cohesion - with the goal to promote increased exchange of IoT technologies deployment best practices, immersion, and inclusion by enhancing opportunities for greater interaction in the regional, European and global arena as part of the IoT key role in digital transformation of the society.

- Enhance coordination of IoT educational activities for IoT-FA.
- Promote interdisciplinary interactions to address the IoT technological and societal challenges and develop support and incentives for programmes across disciplines (IoT, artificial intelligence, robotics, etc.) and industrial sectors.
- Establish a demonstrative and communication campaigns to inform regional, and national stakeholders about the IoT large-scale pilots outcomes and challenges to promote the best practices and support the replication of proven and adopted IoT solutions.
- Enhance coordination of initiatives, and programs charged with IoT research, development, deployment-related work at the regional, national, European and global level.

IoT ecosystems community partnerships - with the goal to create and enhance partnerships that are mutually beneficial to the IoT projects, initiatives, and programmes.

- Develop IoT technologies and applications verification, validation, testing and certification programs in partnership with IoT large-scale pilot projects.
- Increase coordination of IoT large-scale pilot projects with local community needs, and monitor the adoption of IoT technologies and applications in various areas.
- Develop common methodologies and KPI for design, testing and validation and for success and impact measurement; federation of pilot activities and transfer to other pilot areas, facilitating the access for IoT entrepreneurs/API developers/makers and SME in general.

Sustainability and longer-term evolution of IoT - with the goal to promote collective responsibility for the continued development of the IoT large-scale pilots and how to achieve sustainability beyond the pilot duration, and which is the contribution to IoT infrastructures viability in the future including technology, financial and business responsibility.

- The integration and further research and development where needed of the most advanced technologies across the value chain (components, devices, networks, middleware, service platforms, application functions) and their operation at large scale to respond to real needs of end-users (public authorities, citizens and business), based on underlying open technologies and architectures that may be reused across multiple use cases and enable interoperability across those;
- The validation of user acceptability by addressing, in particular, issues of trust, attention, security and privacy through pre-defined privacy and security impact assessments, liability, coverage of user needs in the specific real-life scenarios of the pilot,
- The validation of the related business models to guarantee the sustainability of the approach beyond the project.
- Coordinate IoT-FA sustainability priorities in the IoT research and innovation programs, management, and operational functions.
- Develop sustainability initiatives for the IoT use cases/scenarios applications in coordination with local, regional, and European stakeholders considering new or existing IoT pilot initiatives.
- Propose measures to maintain and enhance the IoT pilots' infrastructure, including their facilities and grounds, application services, and technology resources, to support sustainability.

3.2.1 IoT-FA overview and strategy

The IoT- FA strategy and plan aims that Europe to become a leading player at the global level in several industries, through joint advanced technological development and use of the IoT. This is realized by creating IoT ecosystems supported by open technologies and platforms to support the renewal of the industry and the public sector, increased collaboration between industries, and focused research and development in the common area of interest.

The IoT European Large-Scale Pilots Programme coordination body led by the supporting and coordination actions are continuously monitoring and adapting through the activity groups the common topics, challenges, best practices to maximise the expected impact of the IoT Large-Scale Pilots and coordination actions as outlined below:

- Validation of technological choices, sustainability and replicability, of architectures, standards, interoperability properties, of key characteristics such as security and privacy;
- Exploration and validation of new industry and business processes and innovative business models validated in the context of the pilots.
- User acceptance validation addressing privacy, security, vulnerability, liability, identification of user needs, concerns and expectations of the IoT solutions
- Significant and measureable contribution to standards or pre-normative activities in the pilots' areas of action via the implementation of open platforms
- Improvement of citizens' quality of life, in the public and private spheres, in terms of autonomy, convenience and comfort, participatory approaches, health and lifestyle, and access to services.
- Creation of opportunities for entrepreneurs by promoting new market openings, providing access to valuable datasets and direct interactions with users, expanding local businesses to European scale, etc.
- Development of secure and sustainable European IoT ecosystems and contribution to IoT infrastructures viable beyond the duration of the Pilot.
- Ensure efficient and innovative IoT take-up in Europe, building on the various parts of the initiative (pilots, research, horizontal actions)
- Efficient information sharing across the programme stakeholders for horizontal issues of common interests
- Extension and consolidation of the EU IoT community, including start-ups and SMEs

- Validation of technologies deployment, replicability towards operational deployment
- Validation in usage context of most promising standards and gap identification
- Strengthening of the role of EU on the global IoT scene, in particular in terms of access to foreign markets.

3.2.2 Alignment with IoT European Platforms Initiative (IoT-EPI)

IoT-EPI- was formed to build a vibrant and sustainable IoT-ecosystem in Europe, maximising the opportunities for platform development, interoperability and information sharing. In this context, seven leading research and innovation programs make their technology accessible to 3rd parties. In addition, a strong support and funding structure in the form of open calls and workshops fosters further collaboration.

IoT-EPI and IoT-European Large-Scale Pilots Programme have established the links and developed a framework of collaboration and exchange by organising a common session at IoT Week in Geneva and plan to organise specific sessions in the future connected to various events of common interest. The focus in the first phase is to exchange ideas and present the IoT-EPI projects technology offerings related to platforms interoperability, highlight the components and approaches developed to address IoT platforms interoperability, while the IoT large-scale pilot projects presented the application areas, use cases and implementation scenarios, with emphasis on technology needs and challenges for different scenarios to support the pilot federation activities. The outcome is expected in form of recommendations on interoperability and federation of the IoT reference architectures/platforms and pre-normative and standardisation activities, particularly on semantics, privacy and security; and federation, to align LSPs and the IERC, IoT-EPI projects with AIOTI activities.

The collaborative work is focusing on the alignment and synchronisation of the activities for developing a sound coherent strategy for open exchanges and collaboration between the various activities of the FA. The activities include the promotion for sharing of conclusions and road-mapping with similar activities in countries and regions outside Europe.

The alignment between these two large initiatives will form the basis for IoT technology and applications road mapping to improve decision making by integrating IoT best practice and technological development information from across IoT projects and initiatives into a set of integrated and interdependent plans used to direct IoT strategies for research, innovation, product development, technology advances, and operations/value chain throughout Europe.

The work is part of the strategy work that will be further developed into a roadmap of IoT in Europe that promote and create a mechanism for sharing of conclusions and road mapping at European level, with activities at the national level and similar activities in countries and regions outside Europe. The task synchronises and aligns activities with the work of the AIOTI and the IERC in producing the IoT road mapping and the annual SRIA and the Cluster Book in 2018.

4. IoT-LSP Fields of Interest

4.1 Interaction of Large-Scale Pilots

The aim of CREATE-IoT is to stimulate collaboration between IoT initiatives. As mentioned in section 3.2, this requires strategic and operational synchronisation and alignment through frequent, multi-directional exchanges between the various activities under the IoT FAs. Nevertheless, it also requires cross fertilisation of the various IoT Large-Scale Pilots for technological and validation issues of common interest across the different application domains and use cases. The impact of CREATE-IoT will strongly depend on its interactions with the LSPs, together with other European IoT activities such as the Public Private Partnerships (PPP) and Joint Technology Initiatives (JTIs). The scope of IoT European LSP Programme is to foster the deployment of IoT solutions through integration of advanced IoT technologies across the value chain, demonstration of multiple IoT applications at scale and in a usage context, and as close as possible to operational conditions.

The FA domains are very varied and covering LSPs in Smart living environments for ageing well, Smart Farming and Food Security, Wearables for smart ecosystems, Reference zones in EU cities and Autonomous vehicles in a connected environment. Specific details relative to the launch, testing, deployment and evaluation phases are likely to be equally varied. This heterogeneity means that the focus of CREATE-IoT will be on ensuring that there is a solid element of initial analysis performed on the different concepts to identify non-contiguous activities that can benefit from shared approaches, be they of a technological, policy or business nature. An introduction through the project facts and a field of interests' overview through the project objectives for the different LSP projects is given below.

4.2 MONICA

4.2.1 Project facts

- Full title: Management Of Networked IoT Wearables – Very Large-Scale Demonstration of Cultural Societal.
- Coordinator: FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V., DE.
- Duration: 01.01.2017 - 31.12.2019.
- Type of action: IA - Innovation action (H2020-IoT-2016).
- Website: www.monica-project.eu

4.2.2 Project objectives

The SoundCity Project MONICA aims to provide a very large-scale demonstration of multiple existing and new Internet of Things technologies for Smarter Living. The solution will be deployed in six major cities in Europe.

MONICA demonstrates a large-scale IoT ecosystem that uses innovative wearable and portable IoT sensors and actuators with closed-loop back-end services integrated into an interoperable, cloud-based platform capable of offering a multitude of simultaneous, targeted applications. All ecosystems will be demonstrated in the scope of Large-Scale city events, but have general applicability for dynamically deploying Smart City applications in many fixed locations such as airports, main traffic arterials, and construction sites. Moreover, it is inherent in the MONICA approach to identify the official standardisation potential areas in all stages of the project.

MONICA will demonstrate an IoT platform in massive scale operating conditions; capable of handling at least 10.000 simultaneous real end-users with wearable and portable sensors using existing and emerging technologies (TRL 5-6) and based upon open standards and architectures. It will design, develop and deploy a platform capable of integrating large amounts of heterogeneous, interoperable IoT enabled sensors with different data capabilities (video, audio, data), resource constraints (wearables, Smartphones, Smartwatches), bandwidth (UWB, M2M), costs (professional, consumer), and deployment (wearable, mobile, fixed, airborne) as well as actuators (lights, LED, cameras, alarms, drones, loudspeakers).

It will demo end-to-end, closed loop solutions covering everything from devices and middleware with semantic annotations through a multitude of wireless communication channels to cloud based applications and back to actuation networks. Humans-in-the-Loop is demonstrated through integrating Situational Awareness and Decision Support tools for organisers, security staff and sound engineers situation rooms.

4.3 ACTIVAGE

4.3.1 Project facts

- Full title: ACTivating InnoVative IoT smart living environments for AGEing well.
- Coordinator: MEDTRONIC IBERICA SA, ES.
- Duration: 01.01.2017 - 30.06.2020.
- Type of action: IA - Innovation action (H2020-IoT-2016).
- Website: www.activageproject.eu

4.3.2 Project objectives

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

The project will deliver the ACTIVAGE IoT Ecosystem Suite (AIOTES), a set of Techniques, Tools and Methodologies for interoperability at different layers between heterogeneous IoT Platforms and an Open Framework for providing Semantic Interoperability of IoT Platforms for AHA, addressing trustworthiness, privacy, data protection and security.

User-demand driven interoperable IoT-enabled Active & Healthy Ageing solutions will be deployed on top of the AIOTES in every DS, enhancing and scaling up existing services, for the promotion of independent living, the mitigation of frailty, and preservation of quality of life and autonomy.

ACTIVAGE will assess the socio-economic impact, the benefits of IoT-based smart living environments in the quality of life and autonomy, and in the sustainability of the health and social care systems, demonstrating the seamless capacity of integration and interoperability of the IoT ecosystem, and validating new business, financial and organizational models for care delivery, ensuring the sustainability after the project end, and disseminating these results to a worldwide audience.

The consortium comprises industries, research centres, SMEs, service providers, public authorities encompassing the whole value chain in every Deployment Site.

4.4 AUTOPILOT

4.4.1 Project facts

- Full title: AUTOmated driving Progressed by Internet Of Things.
- Coordinator: EUROPEAN ROAD TRANSPORT TELEMATICSIMPLEMENTATION COORDINATION ORGANISATION - INTELLIGENT TRANSPORT SYSTEMS & SERVICES EUROPE, BE.
- Duration: 01.01.2017 - 31.12.2019.
- Type of action: IA - Innovation action (H2020-IoT-2016).
- Website: www.autopilot-project.eu

4.4.2 Project objectives

Automated driving is expected to increase safety, provide more comfort and create many new business opportunities for mobility services. The market size is expected to grow gradually reaching 50% of the market in 2035.

The IoT is about enabling connections between objects or "things"; it's about connecting anything, anytime, anyplace, using any service over any network. There is little doubt that these vehicles will be part of the IoT revolution. Indeed, connectivity and IoT have the capacity for disruptive impacts on highly and fully automated driving along all value chains towards a global vision of Smart Anything Everywhere. In order to stay competitive, the European automotive industry is investing in connected and automated driving with cars becoming moving "objects" in an IoT ecosystem eventually participating in BigData for Mobility. AUTOPILOT brings IoT into the automotive world to transform connected vehicles into highly and fully automated vehicle.

The well-balanced AUTOPILOT consortium represents all relevant areas of the IoT eco-system. IoT open vehicle platform and IoT architecture will be developed based on the existing and forthcoming standards as well as open source and vendor solutions. Thanks to AUTOPILOT, the IoT eco-system will involve vehicles, road infrastructure and surrounding objects in the IoT, with a particular attention to safety critical aspects of automated driving. AUTOPILOT will develop new services on top of IoT to involve autonomous driving vehicles, like autonomous car sharing, automated parking, or enhanced digital dynamic maps to allow fully autonomous driving.

AUTOPILOT IoT enabled autonomous driving cars will be tested, in real conditions, at four permanent Large-Scale pilot sites in Finland, France, Netherlands and Italy, whose test results will allow multi-criteria evaluations (Technical, user, business, legal) of the IoT impact on pushing the level of autonomous driving.

4.5 IoF2020

4.5.1 Project facts

- Full title: Internet of Food and Farm 2020.
- Coordinator: STICHTING WAGENINGEN RESEARCH, NL.
- Duration: 01.01.2017 - 31.12.2020.
- Type of action: IA - Innovation action (H2020-IoT-2016).
- Website: www.iof2020.eu

4.5.2 Project objectives

The IoF2020 project is dedicated to accelerate adoption of IoT for securing sufficient, safe and healthy food and to strengthen competitiveness of farming and food chains in Europe. It will consolidate Europe's leading position in the global IoT industry by fostering a symbiotic ecosystem of farmers, food industry, technology providers and research institutes. The IoF2020 consortium of 73 partners, led by Wageningen UR and other core partners of previous key projects such as FIWARE and IoT-A, will leverage the ecosystem and architecture that was established in those projects.

The heart of the project is formed by 19 use cases grouped in 5 trials with end users from the Arable, Dairy, Fruits, Vegetables and Meat verticals and IoT integrators that will demonstrate the business case of innovative IoT solutions for a large number of application areas. A lean multi-actor approach focusing on user acceptability, stakeholder engagement and sustainable business models will boost technology and market readiness levels and bring end user adoption to the next stage. This development will be enhanced by an open IoT architecture and infrastructure of reusable components based on existing standards and a security and privacy framework.

Anticipating vast technological developments and emerging challenges for farming and food, the 4-year project stays agile through dynamic budgeting and adaptive decision-making by an implementation board of representatives from key user organizations. A 6 M€ mid-term open call will allow for testing intermediate results and extending the project with technical solutions and test sites. A coherent dissemination strategy for use case products and project learnings supported by leading user organizations will ensure a high market visibility and an increased learning curve. Thus IoF2020 will pave the way for data-driven farming, autonomous operations, virtual food chains and personalized nutrition for European citizens.

4.6 SYNCHRONICITY

4.6.1 Project facts

- Full title: SynchroniCity: Delivering an IoT enabled Digital Single Market for Europe and Beyond.
- Coordinator: AARHUS UNIVERSITET, DK.
- Duration: 01.01.2017 - 30.09.2019.
- Type of action: IA - Innovation action (H2020-IoT-2016).
- Website: www.synchronicity-iot.eu

4.6.2 Project objectives

The SynchroniCity project represents the first attempt to deliver a Single Digital City Market for Europe by piloting its foundations at scale in 11 reference zones - 8 European cities & 3 more worldwide cities - connecting 34 partners from 11 countries over 4 continents. Building upon a mature European knowledge base derived from initiatives such as OASC, FIWARE, FIRE, EIP-SCC, and including partners with leading roles in standardization bodies, e.g. ITU, ETSI, IEEE, OMA, IETF, SynchroniCity will deliver a harmonized ecosystem for IoT-enabled smart city solutions where IoT device manufacturers, system integrators and solution providers can innovate and openly compete. With an already emerging foundation, SynchroniCity will establish a reference architecture for the envisioned IoT-enabled city market place with identified interoperability points and interfaces and data models for different verticals. This will include tools for co-creation & integration of legacy platforms & IoT devices for urban services and enablers for data discovery, access and licensing lowering the barriers for participation on the market.

SynchroniCity will pilot these foundations in the reference zones together with a set of citizen-centred services in three high-impact areas, showing the value to cities, businesses and citizens involved, linked directly to the global market. With a running start, SynchroniCity will serve as lighthouse initiative to inspire others to join the established ecosystem and contribute to the emerging market place. SynchroniCity takes an inclusive approach to grow the ecosystem by inviting businesses and cities to join through an open call, allowing them to participate on the pioneering market place enabling a second wave of successful pilots. They will strengthen the ecosystem by creating a positive ripple effect throughout Europe, and globally, to establish a momentum and critical mass for a strong European presence in a global digital single market of IoT-enabled solutions.

4.7 CREATE-IoT

4.7.1 Project facts

- Full title: CRoss fErtilisation through AlignmenT, synchronisation and Exchanges for IoT.
- Coordinator: STIFTELSEN SINTEF, NO.
- Duration: 01.01.2017 - 31.12.2019.
- Type of action: CSA - Coordination and support action (H2020-IoT-2016).
- Website: www.european-iot-pilots.eu/project/create-iot/

4.7.2 Project objectives

CREATE-IoT's aim is to stimulate collaboration between IoT initiatives, foster the take up of IoT in Europe and support the development and growth of IoT ecosystems based on open technologies and platforms. This requires synchronisation and alignment on strategic and operational terms through frequent, multi-directional exchanges between the various activities under the IoT Focus Areas (FAs). It also requires cross fertilisation of the various IoT Large Scale Pilots (LSPs) for technological and validation issues of common interest across the various application domains and use cases.

CREATE-IoT aligns the activities with the Alliance for Internet of Things Innovation (AIOTI) and coordinates and supports the IoT LSPs in sustaining the ecosystems developed during those projects through mapping the pilot architecture approaches, address interoperability and standards approaches at technical and semantic levels for object connectivity, protocols, data formats, privacy, security, trusted IoT, open APIs and share the road-mapping with international initiatives. The project fosters the exchange on requirements for legal accompanying measures, development of common methodologies and KPI for design, testing and validation and for success and impact measurement, federation of pilot activities and transfer to other pilot areas, facilitating the access for IoT entrepreneurs/API developers/makers, SMEs, including combination of ICT & Art. CREATE-IoT builds strong connections with Member States' initiatives and other initiatives and transfers learning points to the broader IoT policy framework that include contractual PPPs (e.g. Big Data, Factories of the Future, 5G-infrastructure), Joint Technology Initiatives (e.g. ECSEL), European Innovation Partnerships (e.g. on Smart Cities) as well as other FAs (e.g. on Autonomous transport). It maintains a coordinated working relationship with U4IoT that is centred on RRI-SSH.

4.8 U4IoT

4.8.1 Project facts

- Full title: User Engagement for Large-Scale Pilots in the Internet of Things.
- Coordinator: LULEA TEKNISKA UNIVERSITET, SE.
- Duration: 01.01.2017 - 31.12.2019.

- Type of action: CSA - Coordination and support action (H2020-IoT-2016).
- Website: www.u4iot.eu

4.8.2 Project objectives

End-user and societal acceptance is critical to the success of the IoT large-scale pilots. U4IoT combines complementary RRI-SSH expertise encompassing social and economic sciences, communication, crowdsourcing, living labs, co-creative workshops, meetups, and personal data protection to actively engage end-users and citizens in the Large-Scale pilots. It will:

- Develop toolkit for LSPs end-user engagement and adoption, including online resources, privacy-compliant crowdsourcing tools, guidelines and an innovative privacy game for personal data protection risk assessment and awareness, online training modules.
- Direct Support to mobilize end-user engagement with co-creative workshops and meetups, trainings, Living Labs support, and an online pool of experts to address LSPs specific questions.
- Analyse societal, ethical and ecological issues and adoption barriers related to the pilots with end-users and make recommendations for tackling IoT adoption barriers, including educational needs and sustainability models for LSPs and future IoT pilots' deployment in Europe.
- Support communication, knowledge sharing and dissemination with an online portal and interactive knowledge base gathering the lessons learned, FAQ, tools, solutions and end-user feedbacks.

The U4IoT platform will support IoT take-up in Europe by better aligning it with end-user and societal expectations, mutualizing information and learning experiences, and improving communication with the public, enabling Europe to take the lead in IoT user (and market) adoption. U4IoT will work in close cooperation with the other CSA, AIOTI and the IoT Forum who will maintain the platform after the end of the project to continue serving the European IoT community.

5. ACTIVITY GROUPS CONCEPTS AND GOALS

5.1 Framework for collaboration and information exchange

The LSP projects together form the IoT European LSPs programme and a coordination body ensures an efficient interplay of the various elements of the IoT Focus Areas (FAs) and liaise with relevant initiatives at EU and international levels. A coordination tool is implemented by the creation of Activity Groups (AGs) that are addressing topics of common interest across the LSPs. Eight strategic AGs where defined during the LSP kick-off meeting in Brussels (January 2017) to foster coherent implementation of the different LSPs. The eight AGs defined are:

- AG1 - IoT focus area sustainability
- AG2 - IoT standardisation, architecture and interoperability
- AG3 - IoT focus area evolution
- AG4 - IoT accelerators, ecosystems and market place
- AG5 - Trusted IoT, privacy, security and legal frameworks
- AG6 - IoT Urban Context
- AG7 - IoT open environments
- AG8 - Communication, collaboration strategy and liaisons

The activity groups are key enablers for the identification of key performance indicators to measure progress on citizen benefits, economic growth, jobs creation, environmental protection, productivity gains, etc. The coordination mechanisms implemented through the activity groups will help to ensure a sound coherence and exchanges between the various activities of the IoT Focus Area, and cross fertilisation of the various pilots for technological and validation issues of common interest across the various use cases. The relationships are illustrated in Figure 1.

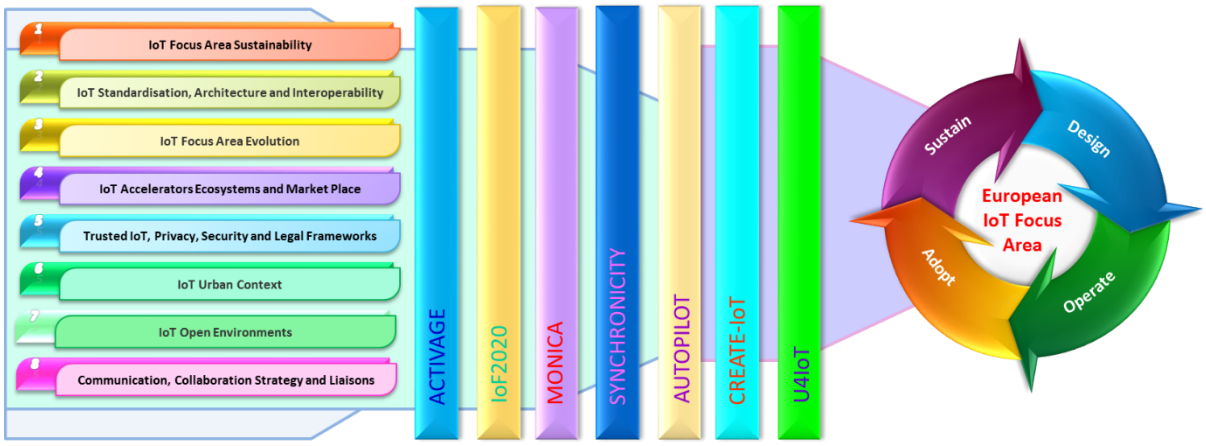


Figure 1: Collaboration framework - Activity Groups, Large-Scale Pilots and Focus Areas.

The issues of horizontal nature and topics of common interest, such as privacy, security, user acceptance, standardisation, creativity, societal and ethical aspects, legal issues and international cooperation, are coordinated by the activity groups and consolidated across the pilots to maximise the output and to prepare the ground for the next stages of deployment including pre-commercial or joint public procurement.

The activity groups support and foster links between communities of IoT users and providers, with Member States' initiatives, and connect with other initiatives including contractual Public-Private-Partnerships (e.g. Big Data, Factories of the Future, 5G-infrastructure), Joint Technology Initiatives (e.g. ECSEL), European Innovation Partnerships (e.g. on Smart Cities), and other Focus Areas (e.g. on Autonomous transport).

The activity groups monitor that appropriate mechanisms are put in place in order that pilots' impact goes beyond involved partners and addresses external communities and stakeholders. This includes the contribution to assure that the IoT infrastructures developed and implemented are viable beyond the duration of the Pilots.

Activity WP/AG	AG1: IoT Focus Area Sustainability	AG2: IoT Standardisation, Architecture and Interoperability	AG3: IoT Focus Area Evolution	AG4: IoT Accelerators Ecosystems and Market Place
D01.01 IoT FA strategy and coordination plan.	WP: Solutions of global/common nature/scope *AG: Achieve sustainability beyond pilot duration*	WP: Standardisation coordination *AG: Standardisation issues*	WP: FA strategy *AG: FA evolution issues*	NA
D01.02 Evolution of IoT FA.	WP: Sustainable European IoT roadmap *AG: Sustainable development into roadmap*	WP: Evolution vs standardisation *AG: Standardisation vs evolution*	WP: European IoT roadmap *AG: Digitizing across value chains*	NA
D01.03 IoT FA Year 1 coordination conference.	WP: Knowledge dissemination *AG: Put sustainability on the agenda*	WP: Conference topics on standardisation (inter alia) *AG: Put standardisation etc. on the agenda*	WP: Knowledge dissemination *AG: FA evolution issues*	NA
D01.04 Common methodology and KPIs for design, testing and validation.	WP: KPI methodology (design, test, validation) *AG: KPIs across LSP projects*	WP: KPI methodology (design, test, validation) *AG: KPIs for interoperability*	NA	NA

Figure 2: Cross fertilisation tool (only a limited part of the matrix are shown)

In this respect, a tool has been prepared for information exchange. For practical reasons only a limited part of this matrix template is illustrated in Figure 2, and shows CREATE-IoT work package activities/results related to deliverables versus activities/results within the different activity groups. Each CREATE-IoT WP is asked to identify AGs in which their contributions are relevant. Once the AGs are identified, a study of deliverables is conducted, identifying potential feedback needs (to be asked to AG participants) and outputs (results to be transferred to the AG). The idea is to identify and make use of synergies and avoid diversities.

On the following, all AGs are described in detail and covering objectives and relevance, collaboration plan (at least for year 1) and expected outcomes and impacts.

5.2 IoT focus area sustainability

5.2.1 Objectives and relevance

The European IoT-LSP portfolio is addressed in light of the IoT Focus Area. The focus is on how to achieve sustainability beyond the pilot duration, and which is the contribution to IoT infrastructures viability in the future. The challenge is to foster links between communities of IoT users and providers, as well as with Member States' initiatives and take advantage of the experience of others in order to demonstrate, grow and support stakeholders to replicate the IoT pilots.

The activity group on IoT Focus Area sustainability is coordinated by CREATE-IoT and U4IoT, providing complementary inputs. The objectives include technology assessment and optimisation, business model validation, approaches to sustainability and replicability. The sustainability issues are addressed considering validation of methodologies, best practices and business models, a common methodology and KPIs for design, testing and validation across the IoT-LSP projects.

5.2.2 Collaboration and plan

The members of the activity group are representing all European IoT-LSP Programme projects (2-3 representatives per project) and plan joint meeting at M06 to discuss, identify and refine the objective, plans, ways of collaboration and outcomes/deliverables. The projects have forum discussions, common workshops and face-to-face meetings. Monthly teleconferences of 2 hours are held. Joint meetings are scheduled roughly every 4 months.

The activity group has regular monthly teleconferences and face-to-face meetings connected with the common events, which allows the IoT-LSP Programme projects to meet. The plan for the next 6 months is to map all the demonstrations and sites of each project and create a catalogue of demo sites describing the venue, partners involved, objectives, outcome, business models and the involvement of local/regional authorities for assuring the sustainability beyond the pilot duration, and considering also, when possible, national pilot initiatives. The plan is mapping the work of the AG inside the IoT-LSP projects work.

- M01 - First draft of the mapping exercise ready for discussions m06 (Presentations, draft document structure, draft web presentation). June 2017 (m06).
- M02 - Description of and mapping al all European IoT-LSP Programme demonstration sites/pilots m10 (Presentations, document containing the description of each site/pilot in one page, web presentation). Common terminology document. October 2017 (m10).

5.2.3 Expected outcomes and impact of results

There is a need to understand the business scenarios/models, practical issues, best practices for the IoT-LSP sustainability and replication and the role played by the infrastructure used by different demonstration sites/pilots. There is a need to identify who will pay for an interoperability solution (and to identify who will exploit them). The IoT pilots are seen as a mechanism for demonstrating sustainability, business benefits, societal awareness and a mechanism for user's acceptance and adoption.

The expected outcome is to have a pan-European overview of the IoT demonstration sites/pilots, identify the sustainability models used, promote best practices and foster links between communities of IoT users and providers, as well as with Member States' initiatives. The development of secure and sustainable European IoT ecosystems and contribution to IoT infrastructures viable beyond the duration of the Pilot are also pursued. In addition, this activity group also aims at ensuring efficient and innovative IoT take-up in Europe, building on the various parts of the initiative (pilots, research, horizontal actions).

Moreover, it emphasises the role and impact of the IoT-LSP as enablers, catalysts and best practice mechanisms for implementing the IoT technologies and applications and support the Pan-European strategy for Digitising Industry by promoting, standard based open interoperable IoT platforms, advanced IoT technology developed around strong technology and application ecosystems. In this context, the expected impact is in validation of technological choices, technologies deployment, replicability towards operational deployment exploration and validation of new industry and business processes and innovative business models validated in the context of the pilots to support strengthening of the role of EU on the global IoT scene. Finally, the group will foster the development of secure and sustainable European IoT ecosystems and contribution to IoT infrastructures viable beyond the duration of the IoT-LSPs.

5.3 IoT standardisation, architecture and interoperability

5.3.1 Objectives and relevance

This activity group covers the proposal of best practices for mapping of pilot architecture approaches; interoperability and standards approaches at technical / semantic levels; architectures that may be reused across multiple use cases and interoperability enablement across those. All these topics imply significant and measureable contribution to standards or pre-normative activities in the pilots' areas, together with interoperability and integration testing on open IoT platforms (e.g. hackathons, plug-fests).

The activity group on IoT standardisation, architecture and interoperability is coordinated by CREATE-IoT and U4IoT projects.

5.3.2 Collaboration and plan

The members of the activity group are representing all European IoT-LSPs Programme projects (2-3 representatives per project). Monthly teleconferences of 2 hours are held. Joint meetings are scheduled roughly every 4 months.

The activity group plan is to provide recommendations on the reference implementation of promising IoT standards serving the interoperability and openness objectives. The plan considers the validation in usage context of most promising standards and gap analysis identification and addresses interoperability, integration, through open IoT platforms used by the IoT LSP projects.

- M01 - Pre-normative standardisation related activities (report). Strategy and coordination plan for IoT interoperability and standard approaches (report). June 2017 (m06).
- M02 - Collection of first inputs about architecture/platform proposals from LSPs to start the discussion (reports, presentations). October 2017 (m10).

5.3.3 Expected outcomes and impact of results

The expected outcome is to provide a validation tool for the usage context of most promising standards and provide a proper gap identification and the measurable contribution to standards or pre-normative activities in the pilots' areas. It also covers the identification of reference implementation of promising IoT standards, serving interoperability and openness, by consolidating results obtained at platform and/or pilot levels through standardization and pre-normative activities performed by the IoT-LSPs projects.

The expected impact is to have a significant and measurable contribution to standards or pre-normative activities in the pilots' areas of action via the implementation of open platforms and validation of IoT architectures, standards, interoperability properties used across the IoT-LSPs. This will also contribute to the validation in usage context of most promising standards and gap identification.

5.4 IoT focus area evolution

5.4.1 Objectives and relevance

Involvement and contribution to the governance of the Digitizing European Industry (DEI) Strategy. Connect with other initiatives including contractual Public-Private-Partnerships (PPPs) (e.g. in the area of Big Data, Factories of the Future, 5G-infrastructure), Joint Technology Initiatives (e.g. ECSEL), European Innovation Partnerships (e.g. on Smart Cities), other Focus Areas (e.g. on Autonomous transport).

The activity group on IoT Focus Area evolution activity group is coordinated by the CREATE-IoT and U4IoT with the goal to be involved and contribute to the governance of the Digitizing European Industry (DEI) Strategy and to connect with the European initiatives (PPPs, JTIs, EIPs, KICs, EU Smart Specialisation Platform) for defining the developments of IoT technologies and applications in digital technologies and in digital industrial platforms across value chains in all sectors of the economy.

5.4.2 Collaboration and plan

The members of the activity group are representing all European IoT-LSPs Programme projects (2-3 representatives per project). Monthly teleconferences of 2 hours are held. Joint meetings are scheduled roughly every 4 months.

The activity group plan is to identify existing links in the LSPs with existing EU initiatives (PPPs, JTIs, EIPs, KICs, EU Smart Specialisation Platform) and mapping the Strategic Research and Innovation Agendas. The activity group gives input to recommendations report of IoT as key

pillar for the digital economy by contributing quantifiable drivers and barriers in the IoT area to the Digital Single Market implementation in Europe and an assessment of the common challenges and the collaboration potential across Europe.

- M01 - Draft structure for input recommendations for IoT as key pillar for the digital economy. June 2017 (m06).
- M02 - European IoT Value Chain integration framework as part of the Digital Single Market. October 2017 (m10).

5.4.3 Expected outcomes and impact of results

The expected outcome is to provide the input from the European IoT-LSP Programme projects to ensure that any industry in Europe, big or small, wherever situated and in any sector can fully benefit from digital innovations to upgrade its products, improve its processes and adapt its business models to the digital change. The activities result in input an participation in the Digital Innovation Hubs for mainstreaming digital innovation across all sectors, help companies to understand digital opportunities and to get access to knowledge and testing facilities, while supporting to define a plan for strengthening a network of Digital Innovation Hubs in Europe. The activities will support to define a plan for better coordination and increased efforts among the PPPs, JTIs, EIPs, KICs, EU Smart Specialisation Platform to strengthen the developments of IoT technologies and applications in digital technologies and in digital industrial platforms across value chains in all sectors of the economy.

Extension and consolidation of the EU IoT community, ensure efficient and innovative IoT take-up in Europe, building on the various parts of the initiative. Strengthen the cooperation, collaboration and the existing links with the European initiatives 5G, FoF, Robotics, ECSEL, Partnership on Smart Cities and Communities, EIP on Active & Healthy Ageing and the FA on Automated Road Transport, though, further alignment of the SRIA that defines research priorities for these domains and the alignment and coordination of regional, national and European research, innovation and deployment.

5.5 IoT ecosystems and marketplace acceleration

5.5.1 Objectives and relevance

The development of relevant and sustainable European IoT ecosystems is a critical cross domain consideration for all LSPs. This sustainability can only be achieved if the ecosystems are conceived as open environments in which new stakeholders can shape, contribute and benefit from the solutions being created. A functioning ecosystem accelerates market adoption, enables the ground to be set for the creation of a marketplace in which data can be traded, and hard-wires innovation into the LSPs, setting the ground for the development of new use-cases. Accordingly, the objectives of this activity group are to:

- Ensure the LSPs are relevant to the multiple users to whom they are directed by integrating them into the design and deployment phase of the LSPs and conducting ongoing user acceptance testing
- Enable the entry of new technology partners by building on the existing network of innovation hubs, start-up incubators and accelerators, SMEs representatives in multiple sectors throughout Europe, accessing the vibrant developer communities across Europe and encouraging their participation in the Open Calls.
- Exchange experiences relating to the business models associated to the use-case to pinpoint how the uses cases deployed in the LSPs can be sustained beyond the EU-funded period; this includes explore how the data used and generated can be traded in an open marketplace, within a given domain (e.g. between domains and on a horizontal level.

The role of Art in making this process more effective is of paramount importance. Through the application of a STARTS (Science, Technology and Arts) approach, the LSPs can apply new perspectives to capturing needs, identifying barriers to adoption and communicating IoT-enabled value creation to a wider audience.

It is worth noting that the term artist in this context includes a broad range of relatively recently developed or re-framed artistic sub-disciplines including self-defined terms such as Live Code Performer; VR and AR Designer; Creative technologist; Multi-media Artist, Transdisciplinary Artist, Digital Artist, Maker, Live Visual Performer and Design Fusionist.

The activity group on IoT ecosystems and marketplace is coordinated by members of the CREATE-IoT and U4IoT consortia. The activities include providing an overview of the business cases addressed through the LSPs and their deployment sites, maximising opportunities for stakeholder involvement, enabling access to open APIs as part of an Open Call process and stimulating the creation and exchange of data.

5.5.2 Collaboration and plan

The members of the activity group are representing all European IoT-LSPs Programme projects (2-3 representatives per project). Monthly teleconferences of up 1 hour are held to agree on priority common actions, exchange views on common ground and agree work to be performed. Input is provided throughout shareable, live documents that can be edited and accessed by all LSP representatives. Joint meetings are scheduled to coincide with other events to ensure optimum use of travel time and budgets.

More broadly, the AG will identify external partners for further collaboration and the exchange ideas. These include the FIWARE IoT Accelerator, companies that have provided IoT analytics reports (i.e. IDC analysis of IoT landscape) or the Vertigo project through which the LSPs can apply for artists-in-residence.

As the LSPs mature, the AG will explore the best ways in which open access can be granted to certain data sets for develop new solutions through the open call process. The discussions will also highlight possible opportunities for co-launching calls addressing shared challenges, for instance, linking food and health, or horizontal themes such as cybersecurity.

The work is likely to evolve organically as opportunities for collaboration between the LSPs become more apparent. The main milestones for the first year are:

- M01-Launch and initial analysis of IoT ecosystems the business cases addressed and the deployment sites. June 2017 (m07).
- M02- Overview of planned stakeholder involvement across the LSPs (users, developers, SMEs and start-ups). Sept 2017 (m09)
- M03- Identification of opportunities to employ a STARTS approach Dec 2017 (m12).
- M04 - IoT-EPI (open-platforms.eu) used as common platform for publication of the Open API's. October 2017 (m12).

5.5.3 Expected outcomes and impact of results

The activity group plan will provide an overview at European level of the IoT ecosystems, their stakeholders, the business cases addressed, the deployment sites and provide a framework within which to explore collaboration on common themes and achieve greater impact.

The LSPs will be provided with a range of tools that will enable them to accelerate innovation and adoption. The AG will also have provided an environment in which new approaches, including STARTs (Science, Technology and Arts) can lead to a more effective deployment that considers user needs. By involving stakeholders in all the stages, the LSPs will stimulate innovation and acceptance and ensure their relevance beyond the EU-funded stage.

By exploring common challenges and the possibility of launching joint calls, this AG will also have a positive impact on how resources are channelled. Through these calls, IoT entrepreneurs/API developers/Makers, SMEs and other stakeholders will gain access to open APIs. Finally, ongoing discussions and debates between the LSPs will fast-track the creation of a marketplace in which the value of data can be explored and traded.

5.6 Trusted IoT, privacy, security and legal frameworks

5.6.1 Objectives and relevance

Stakeholders acceptance validation addressing privacy, security, vulnerability, liability, identification of stakeholders user needs, concerns and expectations of the IoT solutions exploitation of security and privacy mechanisms towards best practices and a potential label (e.g. Trusted IoT). The activity group on IoT standardisation, architecture and interoperability is coordinated by the CREATE-IoT and U4IoT. Address the issues from an European value proposition in a global perspective as countries outside the EU/EEA take part in the consortia to build the IoT-LSPs (i.e. Korea, countries from Latin America, etc.). The activities will look at privacy issues and how these can be tackled in an efficient manner in view of the upcoming new regulations (e.g. the emission of information by smart vehicles or the risk of profiling of citizen's through the analysis of Big Data).

5.6.2 Collaboration and plan

The members of the activity group are representing all European IoT-LSPs Programme projects (2-3 representatives per project). Monthly teleconferences of 2 hours are held. Joint meetings are scheduled roughly every 4 months.

The activity group plan is:

- M01 - Overview of planned activities and priorities. June 2017 (m06).
- M02 - Present the first draft of the IoT policy framework linked with IoT governance. October 2017 (m10).

5.6.3 Expected outcomes and impact of results

The expected outcome is to discuss and adopt the use of an IoT policy framework linked with IoT Governance that will address the issues of horizontal nature and topics of common interest (i.e. privacy, security, safety, societal, ethical aspects and legal issues) in a coordinated and consolidated manner across the IoT activities and pilots to maximise the output and impact of IoT technologies and applications across various domains. The framework need to focus on (personal) data protection, security, safety, liability and net neutrality with a cross-domain IoT approach as part of the Digital Single Market strategy.

User acceptance validation addressing privacy, security, vulnerability, liability, identification of user needs, concerns and expectations of the IoT solutions, validation of key characteristics such as security and privacy. Efficient information sharing across the programme stakeholders for horizontal issues of common interests such as trust, security, privacy, legal issues.

5.7 IoT Urban Context

5.7.1 Objectives and relevance

The activity group on IoT urban context, is coordinated by the CREATE-IoT and U4IoT. The activity group is to address the challenges of dynamic and evolving environments, generating high-volume streams of heterogeneous correlated/non-correlated contextual information of varying quality and complexity considering the increase in user mobility and unreliable

sensors/actuators information in IoT, taking into account the context-aware applications to dynamically adapt their behaviour at run time. The challenge of the group is to address public-private investments needed to modernise baseline infrastructure both for traffic management, utilities and communication (incl. LPWA, 4G/5G deployment, C-ITS), onto which new services and application could be built to support its citizens and their environment. More over the objective is to address the specific needs of the IoT pilots regarding shared governance, investment in urban infrastructure and gaps in the regulatory environment.

5.7.2 Collaboration and plan

The members of the activity group are representing all IoT European Large-Scale Pilots Programme projects (2-3 represent ants per project). Monthly teleconferences of 2 hours are held. Joint meetings are scheduled roughly every 4 months.
The activity group plan is:

- M01 - First draft of the pilot mapping exercise and stakeholder split between Urban Concept and Open Environments activity group ready for starting discussions. June 2017 (m06).
- M02 - Identification of most appropriate LSPs and pilots to be covered by this activity group. First draft of challenges. October 2017 (m10).

5.7.3 Expected outcomes and impact of results

The expected outcome is to have an overview and evaluate the challenges in open environments such as districts, smart cites, by considering specific element like sharing of resources (including data), tendering processes, multi-stakeholders ecosystems and the non-traditional policy issues to grant access to a resource based on the characteristics of the requestor rather than its identity.

The impact includes user acceptance validation, identification of user needs, concerns and expectations of the IoT solutions in open environments. Improvement of citizens' quality of life, in the public and private spheres, in terms of autonomy, convenience and comfort, participatory approaches, health and lifestyle, and access to services.

5.8 IoT open environments

5.8.1 Objectives and relevance

Address the complexity of overlapping contexts in environments such as, highways, farming, ecological systems, etc. and in collaboration with the former activity group on Urban Concept, where same topics are covered but limiting the scope to smart city environments.

The activity group on IoT open environments is coordinated by the CREATE-IoT and U4IoT. The activity group core objective is to address the challenges of dynamic and evolving environments, generating high-volume streams of heterogeneous correlated/non-correlated contextual information of varying quality and complexity considering the increase in user mobility and unreliable sensors/actuators information in IoT, taking into account the context aware applications to dynamically adapt their behaviour at run time.

5.8.2 Collaboration and plan

The members of the activity group are representing all European IoT-LSPs Programme projects (2-3 representatives per project). Monthly teleconferences of 2 hours are held. Joint meetings are scheduled roughly every 4 months.

The activity group plan is:

- M01 - First draft of the pilot mapping exercise and stakeholder split between Urban Concept and Open Environments activity group ready for starting discussions. June 2017 (m06).

- M02 - Identification of most appropriate LSPs and pilots to be covered by this activity group. First draft of challenges. October 2017 (m10).

5.8.3 Expected outcomes and impact of results

The expected outcome is to have an overview and evaluate the challenges in open environments such as smart villages, highways, farming etc. by considering specific element like sharing of resources, tendering processes, multi-stakeholders ecosystems and the non-traditional policy issues to grant access to a resource based on the characteristics of the requestor rather than its identity.

The impact expected covers user acceptance validation and identification of user needs, concerns and expectations of the IoT solutions in open environments. It also aims at improving users' quality of life, both in the public and private spheres, in terms of autonomy, convenience and comfort, participatory approaches, health and lifestyle, and access to services.

5.9 Communication, collaboration strategy and liaisons

5.9.1 Objectives and relevance

Communications strategy to coordinate and support the European IoT-LSPs Programme communicate effectively and meet core programme objectives. Ensure the use of a common terminology in and common messages for promoting the programme to the various stakeholders online (i.e. web platform for exchange/community building, social media, etc.), offline (i.e. organization of workshops and meetings, press releases, media, etc.) and through other channels (European Parliament, public authorities, regional/national governments, etc.). The tasks link the European activities with initiatives in the global arena through reciprocity by promoting cooperation sharing of findings and conclusions and propose ways of collaboration with global initiatives. The key objective of the activity group is to overcome fragmentation of vertically oriented closed systems. The work is being marketed, not as individual projects, but as the "European IoT-LPSs Programme" with the aim of creating a brand for exploitation. The main aims is to share knowledge and plan common activities.

The activity group on Communication, Collaboration Strategy and Liaisons is coordinated by the CREATE-IoT and U4IoT.

The objectives are to design and implement the communications strategy to coordinate and support the IoT LSPs Programme communicate effectively and meet core programme objectives. These include key elements of a communications strategy, common web portal, events, branding, awareness, press/PR plans, web strategies and marketing plans. The communication strategy is aligned with the strategies of IoT-LSPs Programme projects and acts as a reference and reminder for the members of the programme. The communication, collaboration strategy and liaisons activity group is preparing this strategy to provide and effective communications with the goal to:

- Support European IoT-LSPs Programme achieve the overall objectives and impacts.
- Engage effectively with all stakeholders and various ecosystems.
- Demonstrate the success of the work performed by the projects and partners.
- Ensure that people, public authorities, reginal and national representatives understand what the programme does and can follow the progress.
- Change behaviour and perceptions where necessary.

The communications strategy outline what European IoT-LSPs Programme does, what its main functions are, and where and how it operates. During the preparation of the strategy an analysis will be carried out, which involves listing the technological political, economic, and social

factors that could affect IoT-LSPs Programme's work. In addition, the analysis involves listing programme's strengths, weaknesses, opportunities, and threats.

5.9.2 Collaboration and plan

The members of the activity group are representing all European IoT-LSPs Programme projects (There are three representatives from each project in the working group. The representatives are the WPL and task leaders involved in communication, dissemination and exploitation activities.

A graphic representation of the activity group on Communication, Collaboration Strategy and Liaisons, and its interrelations with the LSPs projects and the CSAs, is outlined in the figure below.

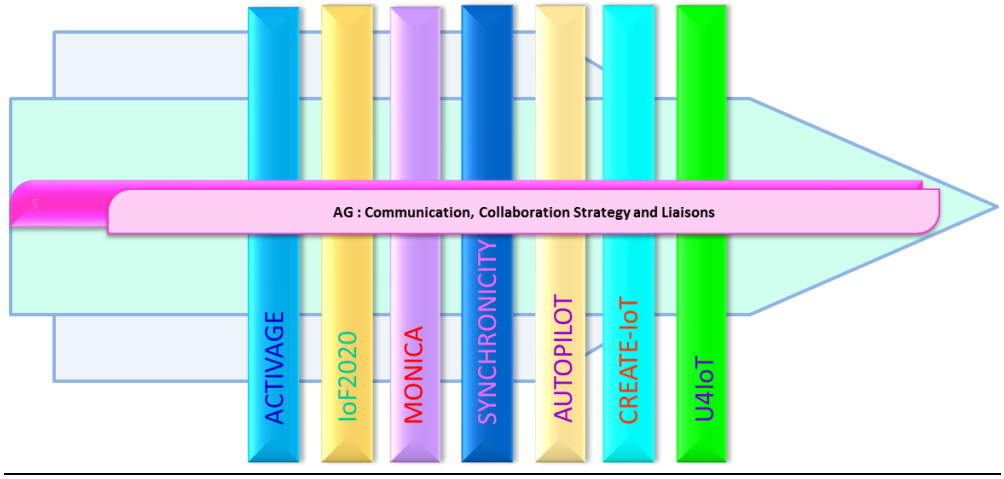


Figure 3: AG on Communication, Collaboration, Strategy and Liaison and its interrelations within the Programme

The activity group plan is:

- M01 – June 2017 (m06):
  - Identification of conferences and events for the year 2017 and the first half of 2018 where to ensure the presence of one or more representatives European IoT-LSPs Programme;
  - Definition and establishment of a viable and effective brand identity for the project and in line with the existing Programme's identity (Production of a logo in different resolutions to print or use in electronic media; production of draft brochures for each LSPs and the two CSAs); definition of common colour themes and styles and creation of a common template for PowerPoint presentations and other externally-oriented documents).
  - First draft, finalization and delivery of D07.01 Communication plan;
- M02 - October 2017 (m10):
  - Finalization of stakeholders' list with contact details to be used in external communication and dissemination activities;
  - Definition of topics and themes for all the webinars to be conducted in 2017 and 2018. Design, organization, launch and execution of Webinar 1.
  - Detailed plan with timeline and frequency for the use of multiple dissemination tools (LinkedIn, Twitter, etc.).

5.9.3 Expected outcomes and impact of results

The expected outcome is to have a common communication strategy for the European IoT Large-Scale Pilots Programme for coordinating and supporting the IoT large-scale projects.

The expected impact is to provide a coherent communication strategy for efficient information sharing across the programme stakeholders to ensure efficient and innovative IoT take-up in

Europe, creation of opportunities for entrepreneurs by promoting new market openings. Promotion of the IoT developments, consolidation of the EU IoT community and strengthening of the role of EU on the global IoT scene.

6. IoT Ecosystems Analysis

6.1 The IoT Ecosystem

IoT brings together things, data, processes, and people through an integrated ecosystem to make networked connections more relevant by turning information into action. As a result, millions of buildings are connected to the Internet through fixed landlines and billions of people are connected to the Internet through mobile technologies. Many billions more "things" can now be connected to the Internet too.

IoT not only leads to increased efficiency and automation, but also to business growth and transformation through better, timelier, and more accurate decision making but the provision of IoT services necessitates partnering with multiple companies (i.e., an ecosystem). A simplified graphic representation of the IoT ecosystem can be sketched out as follows.

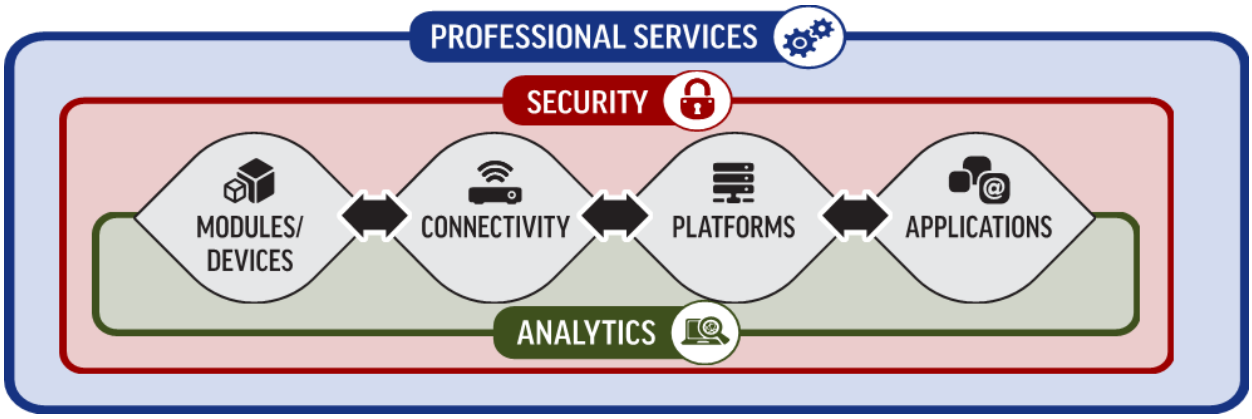


Figure 4: The IoT Ecosystem (the general perspective)

The IoT Ecosystem: The IT industry perspective.

Worldwide survey results from IDC show that no IT vendor emerges as the clear leader for IoT.

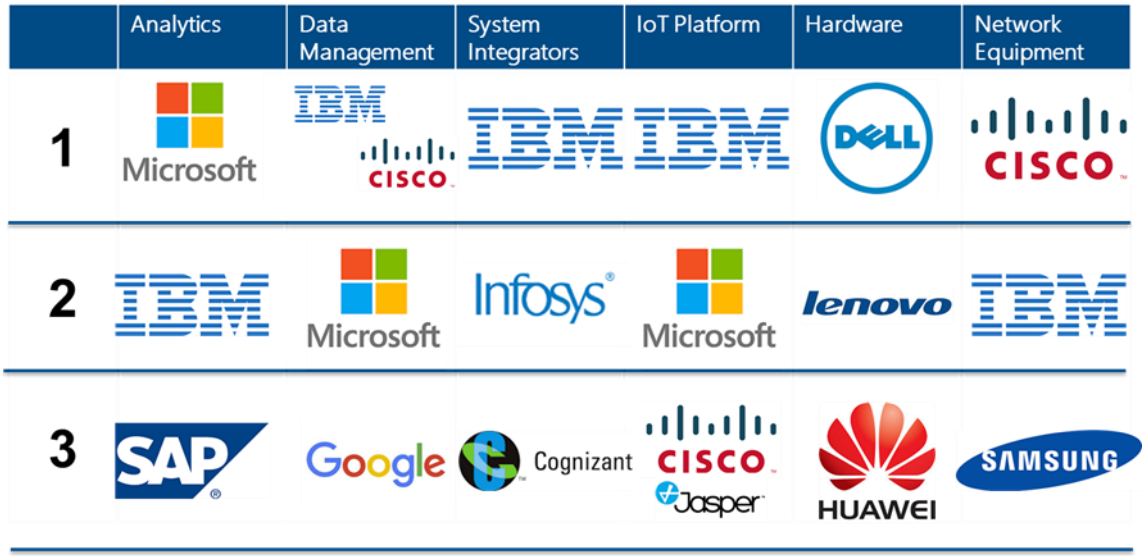


Figure 5: Tier 1, Tier 2 and Tier 3 IT Vendors in the IoT Market worldwide

Within each IoT value chain component, some vendors are perceived as leaders. But survey statistics show that their mindshare is low (the vast majority of respondents do not know who will lead each area of the IoT market). This shows the market is not yet in its complete maturity phase – at least from a vendor perspective.

A graphic representation of the main three tiers of IT Vendors in the IoT Market worldwide is offered in Figure 5. Seen from the IT industry perspective, the IoT ecosystem is complex as well as broad as it stretches from modulus, devices, sensors, all the way to analytics and professional services. Different vendors' type can all legitimately stake a claim to IoT but none of them can claim to cover the entire value chain themselves. As a result, relying on a strong ecosystem of partners is essential. To this aim, partnerships do not have to be exclusive, but they need to be strategic to allow solution repeatability to emerge and drive down price and time to market. The graphic representation of the IoT Ecosystem from the IT industry perspective becomes as follows.

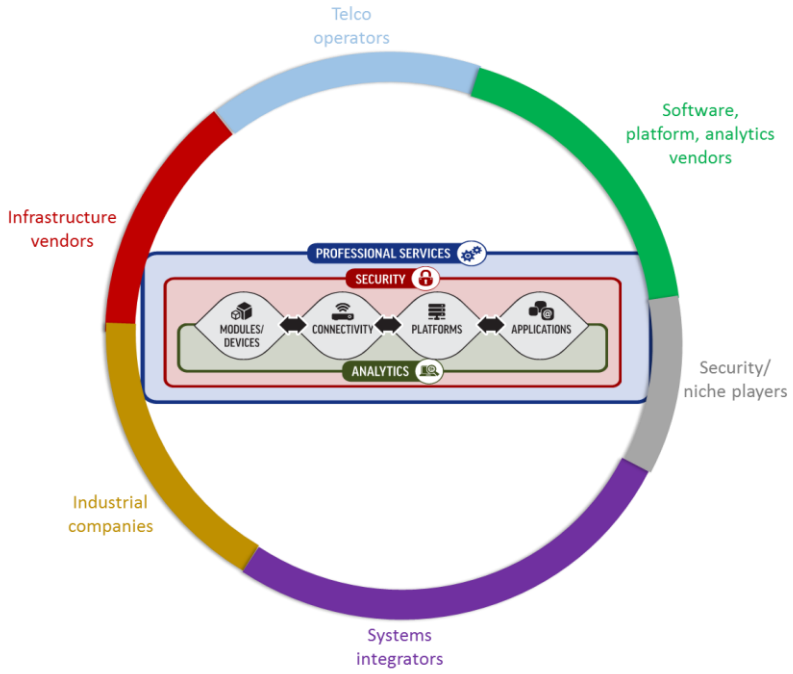


Figure 6: The IoT Ecosystem (the IT Industry perspective)

6.1.1 The IoT Ecosystem - The Users' and Buyers' Perspective

IoT investments from the users and buyers side are still mainly driven by internal IT budget allocations and are steered mainly by the users' IT departments themselves or by specific business units or new business units created to exploit IoT business capabilities. External drivers such as customers, regulatory requirements or business partners' needs are still playing a secondary role but are expected to increase their impact in the near future.

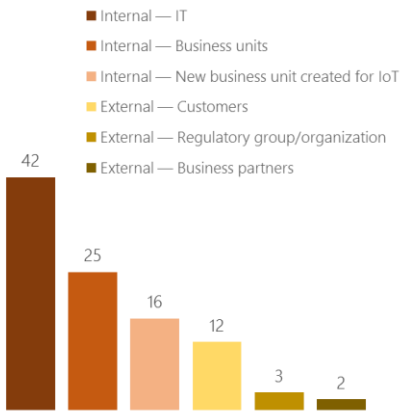


Figure 7: Who is driving organizations' decision to embark on IoT?

Process automation, improvements of business productivity and better customer experiences are among the most cited drivers behind IoT adoption by users and buyers alike. On the other hand, issues related to security, privacy and initial investments features at the top of the buyers' mind in Europe.

Figure 8: Drivers (above) and Inhibitors (below) for IoT adoption

6.2 Policy issues

Sensors, mobile phones, wearable objects, RFID tags, cameras, middleware components, have a common feature: they are all points of entrance of data, often personal data.

Data are the fuel of the IoT Ecosystem, the cornerstone around which all the policy issues related to IoT rotate, which are linked to the free (and secure) flow of data; in this regard, the free flow of data it is in the IoT ecosystem the same as it is within the broader European Digital Single Market Strategy (DSM), namely the main meta-objective to be achieved.

Yet, in order to achieve the free flow of data in the IoT environment, some policies need to be explored and devised to tackle the issues of:

- Interoperability and Standardization
- Contractual Lability
- Privacy and Security.

6.2.1 Interoperability and Standardization

As the European Commission pointed out: "Standardisation is the critical element to deliver a single market for IoT where any device can plug and play anywhere.

It can facilitate the interoperability, compatibility, reliability, security and effective operations on a global scale among different technical solutions, softening (or even eliminating) such fragmentation, stimulating the emergence of new ecosystems, enabling R&D, boosting innovation and reinforcing competitiveness.

IoT standards may support the emergence of business models unleashing the commercial capabilities of systems and device integration"[12].

6.2.1.1 Strategy

Recommendation #1: Mapping the existing IoT Large Scale Pilot projects to track the growth of IoT ecosystems based on interoperable open technologies, data sharing and open data platforms

This will help benchmark successful IoT initiatives and will underscore a variety of IoT deployment models including the requirements and frameworks based on which users and stakeholders can deduce the combinations of technologies and the implementation methodology to optimize privacy and security within each layer of the IoT ecosystem.

Based on this mapping activity, a gap analysis could be conducted to glean the shortcomings of IoT frameworks employed in existing initiatives. This could potentially form the basis of new standards to boost the security and privacy aspects in projects associated with the dissemination of IoT technologies.

Recommendation #2: Gathering a list of existing international standards and maintaining them as the basis for future standardization work on the topic of privacy and security for IoT

Leading international standards developing organizations (SDOs) including the International Telecommunication Union (ITU) and International Organization for Standardization (ISO) have been working on this issue.

Within the ITU, the ITU-T Study Group 20 on IoT and Smart Cities and Communities is the technical group responsible for the development of international standards and specifications to enable the coordinated development of IoT technologies, including machine-to-machine communications and ubiquitous sensor networks. A key part of the work conducted within this Study Group is the standardization of end-to-end architectures for IoT, and mechanisms for the interoperability of IoT applications and datasets employed by various vertically oriented industry sectors.

The Technical Committee in ISO dealing with IoT related topics is the ISO/IEC JTC 41 "Information technology". Within this Technical Committee, the Sub-committee ISO/IEC JTC 1/SC 41 “Internet of Things and related technologies” is dedicated to developing standards for setting up a feasible IoT infrastructure.

6.2.2 Contractual Liability

The IoT creates sophisticated interdependencies between product and service producers. The fact that the IoT ecosystem is complex and that it is hard to map the stakeholders playing therein (e.g. product manufacturers, sensor manufacturers, software producers, infrastructure providers, data analytics companies and other actors involved in the supply of different services, final users), makes the allocation of potential liabilities even harder. It is therefore of primary impportance to find an answer to questions, such as:

- Who is responsible for guaranteeing the safety of a product?
- Who is responsible for ensuring safety on an on-going basis?
- How should liabilities be allocated in the event that the technology behaves in an unsafe way, causing damage? [12]

The IoT interdependency can also give rise to challenges in identifying the root cause of product failures, and in determining where responsibility lies in the event of a problem. The IoT may thus aggravate existing problems of proof concerning non-conformity/defectiveness/unsafety of a product, and issues of causation. Furthermore, under existing EU laws, products and services are treated in a distinct manner. Providing data through an IoT system is considered as a service, and thus falls outside the product liability and safety regimes. Where damage or harm is caused

by supply of false data or by failure to supply data, liability often may become unclear, and claims potentially difficult to enforce.

6.2.2.1 Strategy

Starting from the analysis of existing legislation in this domain, notably in relation to Directive 2000/31/EC on electronic commerce, the Liability for defective products Directive 85/374/CEE, and the Radio Equipment Directive 2014/53/EU, we will explore further this issue in D.05.01 and D.05.02 dedicated to the IoT Policy Framework, as well as in D.05.04 and D.05.05. on the IoT Legal Framework.

6.2.3 Privacy and Security

As the players of the IoT landscape heavily leverage on data – often personal data - to deliver services and increase consumers' welfare, personal data protection and security are key elements in the "value creation chain" of IoT.

In this regard, IoT does not necessarily pose new challenges; it – however – makes traditional challenges escalate and multiply.

For example, data subject's control on personal data becomes more difficult due to the dispersed number of data sources and entities processing personal data; as the chain of providers of IoT services stretches, allocation of responsibilities and enforcement of data protection law become more complex than before; and the same can be said with regards to compliance to the principles of purpose limitation and data minimisation. Plus, it is not easy to identify in each case what the viable legal ground for personal data processing is. The data subject's consent is not always a reliable one; in some cases – especially in the Smart Cities domain – Union or Member State law may constitute the legal basis for personal data processing through IoT deployments.

Such complexity needs – therefore – to be somehow simplified, while at the same time ensuring ad adequate level of security and personal data protection. Individuals shall be granted the opportunity to live in a secure and trustable IoT environment.

This objective will be pursued by working on:

- Privacy Certification of IoT
- Sticky Policies and Privacy Proxies

6.2.3.1 Strategy

Security should be evaluated as an integral component of any IoT system and application and addressed over the whole digital value chain and at all the IoT architecture layers. Building security and privacy in at the design phase (security and privacy by design) reduces possible disruptions and reduce the risk of using complex and expensive solutions to add security to products after they have been developed and deployed. Focusing on security as a feature of IoT devices and platforms, manufacturers and service providers also have the opportunity for market differentiation.

6.2.4 Certification of IoT

To achieve the goal of a Trusted IoT (Label), the certification mechanisms envisaged by Article 42 of Regulation 679/2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data (hereinafter the "GDPR"), are crucial to establish a Trusted and Secure IoT Label, either at European Union or Member State Level.

Create-IoT will work on the converge towards this perspective, through the following recommendations:

Recommendation #1 - Leveraging on and facilitating access to privacy certification solutions developed by the European research community

Several European research projects are currently working on specific certification models for the IoT, including, and not limited to:

- H2020 Privacy Flag project, which is supporting the development of a new assessment methodology and certification model to assess the compliance with the GDPR. It is directly supporting the www.europrivacy.org certification scheme.
- H2020 ANASTACIA, which is researching an innovative model of Dynamic Security and Privacy Seal for IoT deployments.
- H2020 Create-IoT, which is working on the concept of a "Trusted IoT" label for the European market.
- H2020 U4IoT project is developing guidelines on privacy for IoT deployments, as well as a serious game to educate data controller, IoT users and citizens on the risk and obligations related to personal data protection when deploying IoT.
- Concrete initiatives have been launched, such as the creation of a European Centre for Certification and Privacy based in Luxembourg that is supported by several European partners and that should also be taken into account.

In this context, we recommend to leverage on existing resources and development in order not to "reinvent the wheel", but rather to promote synergies among these initiatives and facilitate the access to these various resources and potential services.

Recommendation #2 - Delivering a set of methodologies for privacy and security compliance within the IoT domains

Each of the IoT Large Scale Pilot projects, and each of the two related CSA projects, as well as other projects focused on privacy (e.g. Privacy Flag and ANASTACIA) are already called to deliver privacy and security guidelines, assessments, and methodologies. The work carried out therein can be coordinated by the horizontal Activity Group dedicated to privacy and security bearing in mind two objectives:

- Results must strive to encompass all the IoT related use cases, so as to serve as a toolkit which is deployable in different contexts. This shall be done also taking into account that, in an IoT environment, data subjects often act as "non-users" while data controllers may be represented by mere objects without a dialoguing interface: therefore, a 3D privacy-by-default approach, mixing material and virtual dimensions of data protection, should be encouraged;
- Results should endeavour to advice Data Protection Authorities (hereinafter the "DPAs") and the European Data Protection Board (hereinafter the "EDPB" or the "Board") on the criteria to be used in issuing certification mechanisms or accrediting certification bodies, pursuant to Article 58(3) of the Regulation, with a particular focus on IoT.

Recommendation #3 - Advising DPAs and EDPB on criteria for IoT certification mechanisms and certification bodies' accreditation

According to the GDPR "*A certification (…) shall be issued by the certification bodies (…) or by the competent supervisory authority, on the basis of criteria approved by that competent supervisory authority (…) or by the Board (…). Where the criteria are approved by the Board, this may result in a common certification, the European Data Protection Seal*"[13].

On a good will basis, and in order to support the institutional effort of the DPAs in maintaining – together with the IoT industry – a secure and trusted IoT environment, some criteria may be drawn from projects' deliverables and offered to the consideration of the DPAs exercising their tasks regarding privacy certification in the EU.

Recommendation #4 – Proactively supporting the development of global standards on IoT privacy and personal data protection.

The European Commission and research projects funded by Horizon 2020 program should cooperate to promote international standard on IoT privacy and personal data protection. Such effort should impact global standards beyond the border of European in order to be effective in a market which is global by design. Organization such as the International telecommunication Union should be considered as key priorities to promote the European concepts and definitions of personal data protection

6.2.5 Sticky Privacy Policies and Privacy Proxies

Amongst the solution that need to be further explored to make the automated processing of personal data within the IoT compliant with pre-defined policies, there are the so called:

- Sticky policies and
- Privacy Proxies

The sticky policies can support compliance with the data protection framework by embedding information on conditions and limits to the use of data with the data itself. Thus, those policies could establish the context of use of the data, the purposes, policies on third party access and a list of trusted users.

Privacy Proxies are, instead, a way to offer a data subject real control on how data must be processed when interacting with sensors by being able to express preferences, including getting and revoking consent and purpose limitation choices could be based on the use of privacy proxies. Supported by a device, data requests are confronted with predefined policies governing access to data under the control of the data subject. By defining sensor and policy pairs, third parties requests for collection or access to sensor data would be authorised, limited or simply rejected.

It is recommended to analyse and potentially develop solutions based on sticky-policies and privacy-proxies, which will incorporate a threefold perspective by considering 1) legal requirements, 2) privacy engineering and 3) standards.

6.3 Industrial and societal challenges

6.3.1 Industrial

Even though IoT is often perceived as a great opportunity and major driver for the industrial sector digitalization and next revolution, there are also many factors that are susceptible to hinder this foreseen growth. The technological disruption which has arisen from "Industry 4.0", the current trend of automation and data exchange in manufacturing technologies, has drastically changed how the world is seen today. Moreover, the highly competitive landscape poses urgent questions of change management that manufacturing companies need to address quickly [1].

Machinery performance can now be measured with small sensors connected to the internet, monitoring where efficiency can be optimized. For example, workers will be able to foresee machinery malfunctioning, and intervene in a timely manner. Gartner’s latest forecast predicts 20.4 billion things will be connected by 2020 [3], which will completely change the way we work in several sectors. In the meantime, machine-to-machine communication is fast becoming a reality, and the IoT represents only the first step in that process.

Surveys [4] show consensus on the concern about security and operability being main barriers (above 60%). Other important identified barriers identified on this study show concern about the lack of clearly defined return of investment (above 50%), legacy equipment (almost 40%) and technology immaturity (around 25%). On a lower order of importance, the interviewees

indicated, based on their own experience, several other topics as potential challenges, as the lack of vision/leadership, lack of understanding on top executives, lack of proven business models, quick technology evolution (and related investment delays), heavy upfront capital investment and requirement of business process changes.

Apart from challenges, the industrial implantation of IoT implies also some inherent risks, being cyberattacks the most common concern [5]. The general perception shows stakeholders assume the likelihood of such attacks is extremely high. This also extends to privacy breaches. Exposing personal data or denying services to customer on large industrial companies will automatically translate into heavy public distrust and potential economic losses. Gartner says over 20% of companies are investing in security related issues for their businesses and implying the use of IoT devices by 2017 [6].

Other perceived risk is the potential change on current business models, as there is a probable disruption opportunity. The way organizations operate, organize internal actions and go to market is very likely to change. Moreover, more market entrants will be enabled by a new digital marketplace, where both competition and collaboration will be significantly boosted.

Connectivity and standardization are also major issues for full IoT industrial implantation [7]. On the first case, the current centralized structure using server/client authentication model will be certainly a problem when scaling up the number of devices. On the standardization side, communication and unstructured data handling models are critical to boost wide adoption and also foster interoperability.

There is an emerging technology currently posing as the answer to some of these barriers and risks: the blockchain technology [8]. It is foreseen that Blockchain could be an IoT saviour, lowering barriers about scalability (devices joining an ecosystem, because of the lack of a central cloud solution or entity), authorization (trustability through a shared chain of public/private keys) and data immutability. Nevertheless, its implantation to these ecosystems implies also some additional risks and challenges. First of all, there are currently scalability issues detected in already deployed blockchains as bitcoin. In addition, the cryptographic encryption requirements inherent to the use of this technology might be also a problem for low-power and scarce resource devices such as the ones covered by the IoT domain. Moreover, the local storage needs for each point on the ledger can suppose and additional barrier to its implantation on the IoT domain.

6.3.2 Societal

On the societal side, the increasing on automation level being experienced in some sectors is risking job displacement. As this trend continues to rise, more jobs are likely to be impacted, even those which were genuinely considered as human. One direct example is the potential displacement of drivers as the autonomous car is becoming a reality, being the heavy truck market envisaged to be covered by this technology completely in 15 years [9].

On the other hand, it is also fair to acknowledge that a wide plethora of new jobs will also be created, requiring unique human attributes related to creativity, critical thinking and collaboration. Therefore, it is important to set the focus on new education models, adapting the current system to better prepare young generations to the new digital workplace.

IoT is a set of key enabling technologies for interconnecting robustly a large number of heterogeneous smart devices via the Internet. IoT's main purpose is the improvement of the quality of people's lives by offering services quickly, effectively and in a non-pervasive way so that critical situations can be avoided or addressed. IoT is a prominent set of technologies offering all the necessary tools in order to build applications and services to address industrial and societal challenges.

Until now, IoT tools and practices have been tested in rather small-scale experiments, thus, now ecosystems are created in order to test these practices in more realistic environments.

Main challenges that should be addressed are the improvement of health and the quality of life of people, with a focus on the elderly.

The average age of people around of the world tends to increase as a direct consequence of the advances of technology and science. There are many people that need just a little amount of help to be independent, self-sufficient, secure and safe in their own house and do not need to be assigned with a personal assistant or admitted to an elderly home or a hospital. These issues can, for example, be addressed through a deployment of an IoT network inside a patient's home.

Wearables can be utilized to monitor the vital signs of the patient and in case of irregularities a signal can be sent to the appropriate doctor or medical staff. Temperature sensors can be installed in the rooms to regulate the temperature, avoiding too low or too high temperatures which can affect the patient's health. Moreover, emergency buttons or microphones could be deployed to give the ability of notifying an emergency unit in critical cases. There can be also a device reminding the patient about taking their medication at pre-defined times according to their doctor's advice.

The deployments and services developed for the latter challenge should be sustained for long periods of time, should be cost and energy efficient and self-monitored for improved reliability especially regarding the devices that are used for emergencies.

For example, the wearables mentioned above, should be battery-charged, thus consuming low energy and have limited transmissions. Moreover, the hardware used in case of emergencies should be continuously monitored using a sanity-check service to ensure their proper functionality, despite the fact that they are not frequently used. Since these devices are running critical services, their functionality must be guaranteed and they have to be always connected.

Another challenge that emerges from the development of IoT ecosystems is the enhancement of competitiveness between industrial entities, their involvement in new markets and the improvement of their products so that they meet the new societal and industrial IoT requirements.

This is more evident in domains like health or active and healthy ageing, were the advent of IoT technologies gives opportunities to start ups and especially SMEs, which were not active in this domain before, to enter into this market with smart products. This will result in the economic growth of the SMEs as well as to the creation of new job opportunities since new technologies and new products require new expertise.

6.4 IoT activities

IoT technologies and innovations are currently impacting and will continue fostering development on different sectors considered as core for the European industry [10].

- **Healthcare and wellness**. This sector is an optimal placeholder for comprehensive IoT implementation. Closely monitoring health care treatment, cost and availability is key to boost the impact in a society striving for healthier and older citizens. IoT is key to improve patients' care and provider use of assets, revenues and costs. An efficient implantation would potentially change the way it is currently delivered.
- **Living environments**. With more and more population living in cities and spending most of their time indoors, there is a great challenge on providing living environments. Areas should be adapted and optimized to certain activities, such as exercising or working for home, modulating the environment to maximize comfort.
- **Buildings**. As intelligent Building Management Systems (MNS) are currently being integrated on most cities, the number of IoT devices and networks dedicated to building control and automation are rising rapidly. This extended control of building data allows

managers to efficiently use energy. The human intervention to guarantee efficient operation is, therefore, reduced.

- **Energy**. Following the trend initiated by Smart Grids, the energy sector is currently on a process of digitalising and connecting the whole value chain. In this case, this is directly related to IoT, as this implies connecting altogether all smart meters at customer side, providing information about the energy consumed. In addition, the grid itself and all energy sources are also being monitored and automated to minimize the maintenance costs.
- **Farming and food security**. Embedding IoT devices on farming activities enables the full control of the life cycle for product, from crops to the final client. The challenge here is to optimize the behaviour of each element according to its role on the smart farming system, while assuring maximum quality and security on products and reducing the ecological footprint.
- **Wearables**. New and advance technologies (including organic electronics, nanoelectronics…) are being embedded into clothing together with communication and computation features, making these elements IoT devices potentially connected to Internet. This will enable novel functionalities for clothes, fabrics, patches, watches and other wearable devices.
- **Cities**. Most important cities all around the world are implementing Smart City features. These features include, apart from a baseline ICT infrastructure, wide deployments on IoT devices for a number of vertical applications, such as energy management, lightning, mobility, waste management, etc. Seamless communication, interoperability and security are key aspects to be covered by smart cities.
- **Mobility**. The concept of Internet of Vehicles, including vehicle to vehicle and vehicle to infrastructure interactions, is the future trend for smart transportation. IoT plays a key role as vehicles are equipped with an increasing number of connected sensors, devoted to mechanical and security purposes together with comfort and user-related needs.
- **Environment**. One of the first uses of IoT devices was for environmental purposes. Sensors are currently being used for monitoring air and water quality, atmospheric and soil conditions, noise pollution… They can also be used to trigger alarms and optimize the decision making on emergency situations such as earthquakes, tsunamis, etc.
- **Manufacturing**. Factories were usually isolated and operated as independent silos in the past. IoT is disrupting this trend, penetrating on the infrastructure and digitalising the manufacturing system. This opens the door for optimizing the manufacturing process, optimize the energy consumption and reducing the maintenance cost of machinery.

6.5 IoT business models

The development of the IoT is expected to have a significant impact on the business ecosystems, transforming value chains with new opportunities and creating new business models. In this section, we present an overview of the impacts of IoT on business models followed by a vision more specific to the vertical of the large-scale pilots.

The objective of this section is to provide a vision of the business ecosystem context in which the large-scale pilot will deploy. The activities of CREATE-IoT and of the large-scale pilot will build upon this context to define the best exploitation strategies for each project.

6.5.1 General impacts of IoT on business ecosystems

The development of the IoT and its adoption in various industries is set to have deep impacts on the way products and services are used and consumed. Specificities will vary from industry to industry, but we focus here on three major trends that extend cross industries.

6.5.1.1 New connectivity providers in the value chain

The demand for connectivity in vertical industries will strongly increase as well as the number of B2B subscriptions. This will impact the connectivity value chain, with new players and new roles.

A more complex value chain of connectivity providers

The emergence of new communication technologies (such as LPWA and 5G) will impact the existing connectivity ecosystem. Indeed, they will not only enable new applications and servicers but also enable more new actors to provide connectivity and infrastructure.

The virtualisation principle of 5G, for instance, will provide from the end-user perspective a unified network relying on several connectivity providers exploiting various technologies and infrastructures. It can be thus expected that more actors will participate in the connectivity value chain.

Current connectivity providers (MNOs, MVNOs) will take the opportunity of these new technologies to try to diversify their offer and address new market segments (in specific verticals, including manufacturing) as a way to compensate declining consumer revenues.

Hardware equipment manufacturers can also see these new technologies as an opportunity to diversify their business modelling bundling equipment with connectivity service provisioning for example in the small cell area.

Some vertical solution providers, and potentially manufacturers, will also play a role in the new communication value chains, not only as content and service providers, but also as connectivity provider, infrastructure providers.

The opening of vertical markets will also open up space for existing actors of the wireless industry to target specific roles for vertical industries.

More vertical specific connectivity offerings

Verticals industries (such as automotive, health or agriculture) have very specific requirements, which can be conflicting with traditional consumer requirements in terms of connectivity. This opens up more opportunity for specialised actors targeting industries with specific demands.

New communication technologies will overall lead to a diversification of the connectivity service offering, in the vertical domains.

The business model of new connectivity providers will concentrate on the metrics that are essential to the vertical use cases success such as latency and the reliability of autonomy rather than the traditional bandwidth consumption of consumer markets.

Various price schemes could be offered based on the quality of service. Vertical specific offers will also increasingly bundle together not only connectivity but access to content, vertical specific services and a quality of service guarantee.

6.5.1.2 Product as a Service

The IoT is a key pillar of servicisation by various industrial players, led by the heavyweights. It is a powerful wave that could shake the current ecosystem in various verticals. This will modify current business models with a more customer-centric commercial approach, and implies new business models through additional services, new revenue models, and opportunities outside vertical domains.

A more customer-centric commercial approach

Through servicisation, the main features of the commercial relationship between supplier and demand are transformed:

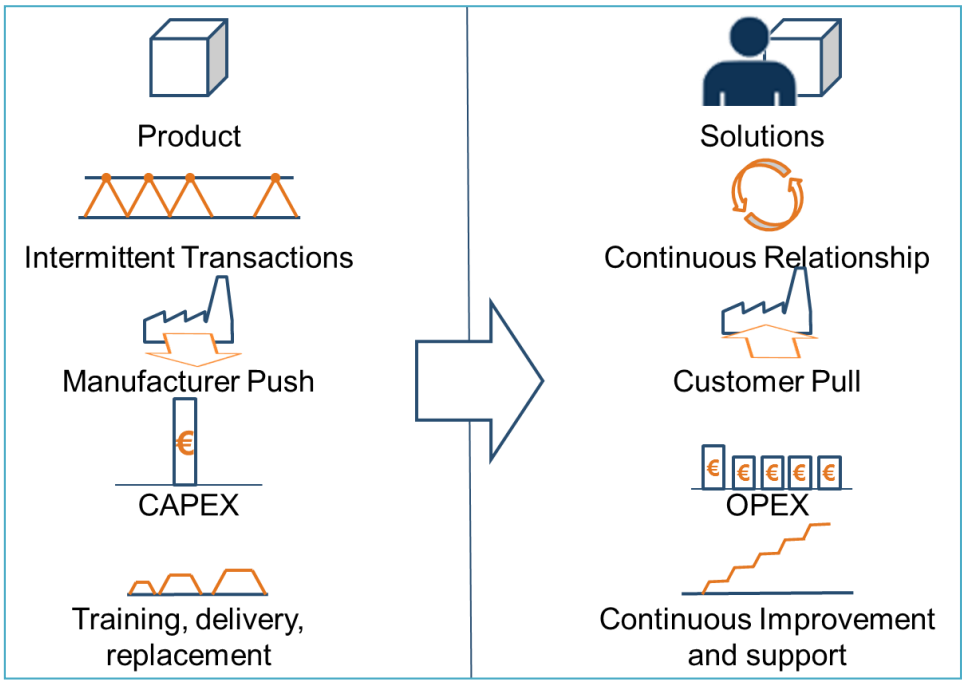


Figure 9: Effects of servicisation on customer relationship [23]

- **Products to solutions**. The manufacturer does not sell a product but solutions including products with additional (paid) services.
- **Transaction to relationship**. A 'one-shot' purchase is transformed into a recurrent relationship between supplier and client. On the merchant side, it is the opportunity to introduce a lock-in configuration.
- **Manufacturer push to customer pull**. Servicisation reinforces the focus on the management of the customer relationship as the solution could fit customer demand if it could evolve over time.
- **CAPEX to OPEX**. Users could also benefit from this shift as depending on their financial situation, they would prefer an OPEX model (based on recurrent costs referring to service billing) rather than a capex model (one-shot costs, even via amortisation referring to the product acquisition). This could lead to a more flexible model, which could stimulate a higher adoption of these connected products.
- **Continuous improvement and support**. The customer relationship evolves from ownership of products over a definite lifespan (with necessary training periods and replacement) to continuous usage of a solution with regular improvement and support by the provider.

Additional revenues from services

The first step in the movement toward servicisation of industry is often to try to bundle additional services to existing product offering.

Indeed, two types of generic services will emerge thanks to the connected product:

- Connected-product life-cycle management provides new insights into product usage, which can be leveraged to make servicisation much more efficient for the supplier—for instance, by using remote condition monitoring instead of costly on-site equipment checks.
- New digital services could create completely new service models, in which a predictive maintenance solution can be used to sell improved service-level agreements (SLAs) with greater guaranteed uptime, for example.

In addition to the service revenue for the industrial player (product manufacturer), the customer also optimises the use of the product, achieving cost savings through, for example, breakdown prevention or optimal fuel consumption. This win-win situation thus provides benefits to each player.

From ownership to usage: innovative pricing models

With more services and less product-dependent revenue, the industries see a tremendous opportunity for deep business shift. Indeed, the module brings a new value to the device/machine, with valuable and monetisable data. It allows the company to develop **subscription-based models**, as is already the case with some selected industries or verticals such as security.

It could even develop advertising/marketing services. Indeed, in variety of cases, the IoT can make it possible to create **new pricing solutions based on real usage** (pay-per-use). This would allow companies to distinguish themselves in the most competitive sectors where pricing formulas are key to market survival. This type of pricing is an integral part of the new services that IoT enables, such as real-time pricing that makes it possible to implement occasional promotions remotely.

Pay-as-you-go (Product as-a-service)

This model is based on the substitution of the product bill by charging a service. Pricing is based on usage and no longer on the product acquisition. The end user does not pay for a product at all but for a service solution. This configuration is also gaining traction given that, for key businesses; product acquisition (aka the total cost of ownership - TCO) could be a financial issue, especially for premium products.

Players in some industries (transportation is one such) are already using it, with a model based on the basis of per kilometre or time units.

Pay-per-outcome

Emerging and innovative business models are entering the scene. To better meet their client expectations such as in terms of cost optimisation, in addition to related services, some industrial players provide a model where the client is charged only if the contracted expectation is completed. For instance, the Michelin EFFIFUEL solution charges its clients only when the fuel cost savings are achieved.

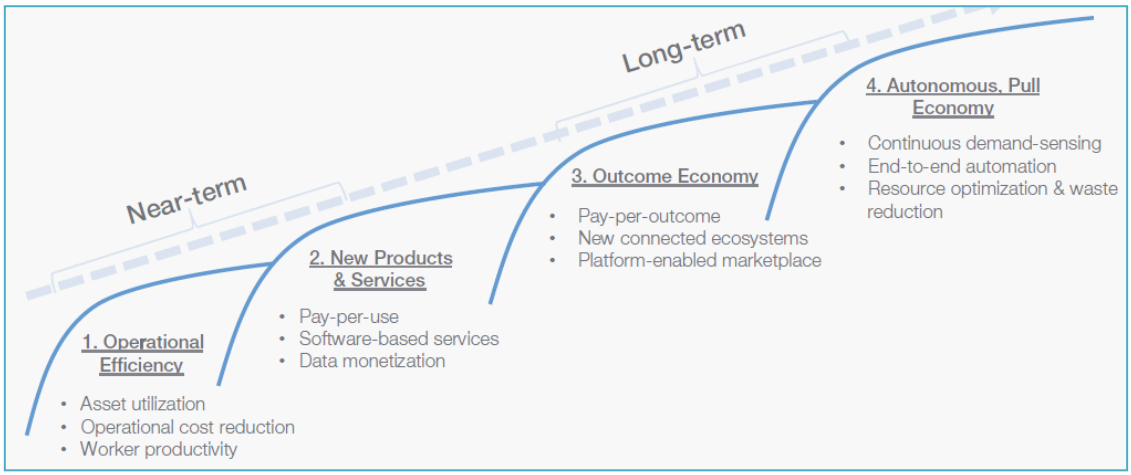


Figure 10: Roadmap of different services offered by industrial players [21]

6.5.1.3 Data monetization

Data will play an important and central role in the future as many player strategies aim to leverage the data collected from the connected objects, for business reasons chiefly.

It is important to distinguish different configurations, whether data relate to consumer or business clients as opportunities and related impacts on the ecosystem should be very different.

The main interrogation for each topic is quite similar as it is based on the ownership of the data itself and its related control. This is the origin of the new supposed paradigm: who can sell data to whom (in the case where `data could be sold)?

Data owned by business clients

Here, the data is generated by the product itself in its working/operating situation. The data is mainly provided by product manufacturers.

The objective is dual and opportunities could be shared by anyone on the value chain, as a win-win configuration:

- **Users can make cost savings**
- **Product manufacturers can generate additional revenues** through service proposition.

Nevertheless, the product manufacturer (also the service provider) could be either the product assembly company or even the part supplier. Here lies the main shift in this configuration, as the supplier could directly address the end-user company, avoiding the product assembly company [22].

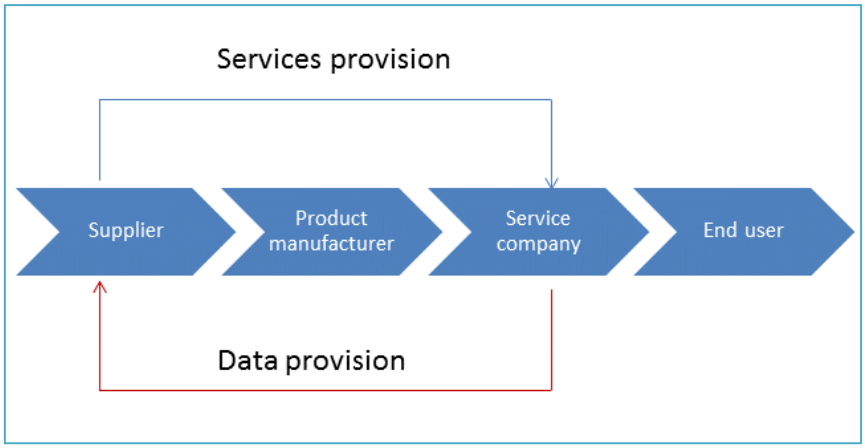


Figure 11: Data resale to service company

Theoretically, the connected products could become an ecosystem shaker. However, for the parts suppliers there is a huge risk of bypassing its own current clients. Hence, it is a risky strategy as service provision will remain a marginal business for a long time yet, in terms of the breakdown of supplier revenue.

Data owned by consumers' clients

Pure consumer relationship

Here, data is generated by end-user behaviour but it could be provided by other players (mainly the product manufacturer).

Many opportunities could be provided by the exploitation of consumer data. They are mainly based on the resale of data generated by the objects. In exchange to this data, the end user could therefore be allowed to receive several discounts which could be applied on:

- **The device cost itself or even on the service subscription** (connected car service for instance).
- **The consumer bill from a vertical player**. Main players interested thus far by this system are chiefly insurance companies and power companies. Several other industries could be interested by the data generated.
- **Other alternative services and products**.

Insurance companies have already pioneered in this space by launching some offers focused on wearable uses. One of the most-advanced services comes from Discovery based in South Africa. For the first time, an insurer will directly collect data, which will be provided on a voluntary basis, for the health of its customers. Nevertheless, it is not known whether the data is monetised here or provided for free by the wearable manufacturers.

These deployments are still marginal as people are quite reluctant to be tracked (lack of acceptability). Indeed, similar solutions in the automotive vertical (pay-as-you-drive offers, where the billing is based on driving behaviour) have already existed for years and adoption is low, even though growing. This kind of solution has been launched by challenging players (new entrants), trying to attract the less risky clientele (who drive well) and therefore the most profitable.

This kind of solution therefore raises privacy issues and Axa for instance stopped communicating around its partnership. In many countries, the market does not seem to be ready to adopt this solution.

B2B relationships including use of data generated by consumer behaviour

Here, the data is generated by the user behaviour but the service is not provided to them but to a third-party company.

In the automotive industry, for example, a supplier could sell data directly to the insurance company, from the data which they can collect through the sensors embedded into different parts such as seats or seat belts. This could provide additional metrics in order to fine-tune the insurance profile (instead of basic measures based on positioning/location and speed) through a dedicated 'black box' which is currently provided, for the pay-as-you-drive application).

As was the case in the previous section, this could appear to be a seriously risky strategy by the suppliers as they bypass their own clients, mainly in a highly competitive market (one client for many suppliers, which is the case in automotive and aeronautical industries, for instance).

It could also be seen as a very fastidious process (how to sell it?) for a niche market.

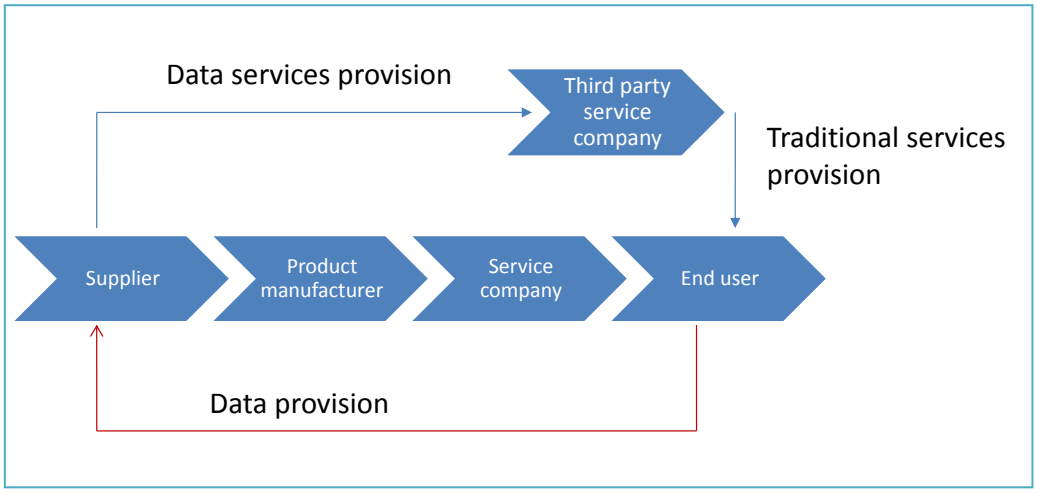


Figure 12: Data resale to a third-party service company [22]

Finally, the main shift in these industries which can be easily anticipated remains that of insurance services being by suppliers or product manufacturers directly. By doing this, they could also strengthen their servicisation strategy.

6.5.2 Impacts of IoT on SmartCity business ecosystems

SmartCity deployment can take several forms and address different aspects of the urban life and citizen's needs. We cover here potential evolutions of business models over four main challenges of the modern city: mobility, the environment, public safety and smart metering.

6.5.2.1 Urban mobility

Managing mobility is one of the key challenges for smart cities. It is an extremely sensitive subject, and can create a tug of war between public policies and citizens' individual freedoms.

This can lead to conflicts of interest, but also create new conditions that tend to alter mobility-related behaviour, in a bid to improve quality of life in the city: reducing congestion, pollution, reclaiming the urban space for pedestrians, etc.

The digital revolution is one of the driving forces behind changing approaches to mobility in the city, either by optimising existing systems, or by offering up new alternative solutions.

Services

For several years now, cities have been reviewing their public policies regarding transportation, to:

- Change the modal split in transportation by restricting the use of individual cars and developing public transport systems, and so lessening cars' stranglehold on urban traffic, optimising parking, reducing toxic emissions, etc.;
- Improving the time, it takes to get from A to B, by offering residents alternatives to public transport which, despite all of the city's efforts, cannot meet all of users' requirements.

On the public policy front, digital solutions can be employed to:

- Improve information on the city's mobility solutions, notably from a multi-modal angle;
- Optimise traffic conditions, notably thanks to the use of real time data;
- Promote the development of alternative forms of mobility (car sharing, bike sharing);
- Transform urban mobility schemes, notably by introducing regulated zones: congestion pricing (city tolls), changing the price of parking, access to carpooling lanes[1]…).

The development of new urban mobility services is capitalising on the latest technical innovations, and particularly those to emerge from the Internet of Things. Among the many innovative mobility solutions, let us cite:

- Managing parking using a vehicle detection system in available spaces, which supplies the information to a mobile app or a street panel that indicates available parking spots to drivers, and offering the ability to vary the price of a spot based on demand, day of the week and time of day, i.e. applying the principle of yield management to parking;
- Measuring city road traffic in real time, and so feeding information to:
  - Road traffic app for people and businesses;
  - Traffic light management system (modulating waiting time based on traffic);
  - User information system that displays traffic information on road signs;
- Real time driving time calculator that makes use of the different data coming either from sensors or third party information systems (e.g. public transport companies' information systems).

Business models

The business model for this type of service is not yet set in stone, and will continue to evolve in the coming years.

Government involvement is still heavy in this sector, partly because of the city's expertise and responsibility in managing mobility, and partly through support for innovation.

This government support can come from different levels: European, national, regional or local. For services that it is mandated to manage, either directly or through public service contracts, the

[1] Certain cities in the United States

city is involved as much in the investments it makes to deploy the required sensors, and all of the elements along the data processing chain, as in the system's operation.

Private sector involvement takes several forms: for start-ups, it will mean targeting investments in new markets for mobile services that tap into mobility-related urban data. For other companies, it could mean much more substantial investments.

Most often, these mobility services may not generate revenue directly (not least due to the very prevalent culture of free services amongst users). But some services, such as optimised parking space management, create an opportunity to improve the profitability of parking, and so to generate additional revenue. This revenue will in turn help to amortise the investments, or at the very least to cover operating costs.

6.5.2.2 Urban environment

Applying digital technologies and IoT to urban environmental issues will be analysed for three fields of application:

- Measuring and monitoring urban pollution (notably air and noise);
- Waste management;
- Managing water and lighting used to serve the common good (public parks and green spaces, streets, etc.).

These three fields of application contribute to the quality of life that the city brings to its citizens. The growing awareness of the imperatives of sustainable development is leading cities to seek out new solutions for managing urban spaces, while reducing direct costs (for street lighting, watering green spaces or waste collection) or indirect ones (positive externalities of reducing urban pollution). IoT and digital technologies open the way to new solutions that meet the challenges of improving the urban environment and the quality of life in the city.

Services

Table 1: Using digital technologies and the IoT for environmental applications [23]

	Role of IoT
Street lighting	Beyond replacing old light bulbs with LED systems, integrating sensors on street lights enables optimised management by varying the intensity of the light, i.e. dimming, based on several criteria: whether or not cars or pedestrians are present. This function can be managed on different scales: individual street lamps, or in a centralised fashion for a neighbourhood or even the entire city.
Waste collection	Sensors for detecting how full waste/recycling containers are (currently used chiefly for voluntary disposal receptacles for paper or glass recycling), can help in planning pick-up routes, and so to optimise spending. Sensors can also be installed in household waste containers to accurately track the number of collections, for instance, with a view to monitoring pick-up operations.
Air pollution	Already deployed in cities' dedicated air pollution monitoring networks, which rely on a small number of measuring stations, new sources of sensors can be mobilised to improve the level of air pollution measurement. This could take the form of a public initiative seeking to increase the density of the measurement network (a good example is the Array of Things solution out of Chicago, for installing sensors on public lighting or other towers or poles in the city), or a crowdsourcing approach involving citizens: sensors could be installed on smartphones, for instance.

Business models:

Implementing smart services such as smart street lamps can be handled by the city itself, which would generate a reduction in operating costs and so allow the city to amortise its investment in the medium or long term.

These street lamps can also be deployed by a private company under contract to the city. When cities establish a public street lighting contract with a private vendor, the city pays the contractor to fully manage the city's lighting (deployment and maintenance). In the case of smart street lamps, and when an entirely new centralised system does not need to be deployed or all of the street lamps replaced, the private contractor may, for instance, not charge the city an additional fee and remunerate itself on the energy savings that are generated.

The same logic applies with smart waste containers, i.e. they can either be managed directly by a city department or contracted out. The business model is also based on the savings generated and on optimising waste collection routes.

These economies have been proven, but nonetheless differ from city to city and depend on various factors (waste production, weather, season, the population's attitude to waste, etc.). Some smart street lamp initiatives that have already launched are forecasting at least 10 years before becoming profitable. The RoI period for waste containers appears to be even longer than that.

Platforms for monitoring urban pollution do not have any particular business model as yet, to the extent that the city (or another player) invests in a system of sensors, takes the reading and models the results. But the city can take certain steps or impose restrictions, such as speed limits, road delineation, installing traffic lights, etc. as air or noise pollution reduction measures.

6.5.2.3 Urban public safety

As cities become more crowded, both the urban environment and its citizens become increasingly sensitive to the many events and circumstances that can affect public safety. There is a huge temptation to engage in full surveillance of the city, notably to reduce the financial and social impact of felonies, crime and other accidents, acts of vandalism or deterioration.

The development of digital technologies, and now the IoT, the potential offered by data processing, the deployment of data collection and capture devices (starting with video), open up prospects for strengthening safety and security in urban spaces, on transport networks and other places that are open to the public, not to mention on private property.

Services

There are several reasons for installing CCTV networks:

- Preventing technical incidents is the predominant reason for installing cameras, the images from which are both looked at directly and also, increasingly often, analysed using software;
- Preserving the integrity of these facilities; misuse and intentional damage require rapid interventions for certain equipment, the functioning of which might affect thousands of people;
- Compensating for the reduction in the human workforce responsible or operating the equipment;
- Increasing the crime/misdemeanour clearance rate by assisting police forces in their work.

Public safety is steadily taking advantage of an array of digital innovations, and particularly the Internet of Things, thanks to the installation of sensors and different locations around the city. The fields of application include:

- Mobile applications or panic buttons for rapidly reporting an emergency (police, fire department, ambulance…). When combined with this type of alert, a more general system allows emergency services to locate the incident, and to automatically train nearby cameras on the location to confirm the reported incident. Police and/or emergency vehicles in the vicinity will be automatically alerted, and very quickly supplied with all of the necessary information.

- Video surveillance cameras with an automatic image analysis system. This system makes it possible to detect in the multiple streams of images that are captured around the clock, the movement of crowds, abnormal behaviour (attacks, fights, someone falling down, etc.), gunshots, traffic accidents, abnormal noises… If the system detects an anomaly or a disturbance on one of the cameras, the police and/or emergency services control centre is alerted, and they will take the necessary measures to address the situation. The system automatically pinpoints the incident's exact location.
- Systems for performing post-facto analysis of incident data: using a database that logs incidents by location, type of incident (assault, fire, theft, vandalism, heart attack, fainting, etc.) and by cross-referencing that data with other relevant data (type of lighting, businesses in the vicinity, weather, season…), the system can determine the most high-risk situations. The purpose of these systems is to anticipate high-risk situations as well as possible.

Business Models

The business model for this type of service is still based mainly on government spending, and projects are usually part of broader homeland security policies.

This goal is often the source of large-scale initiatives involving the creation or renovation of control centres, the installation of CCTV cameras and public debates over the use of existing data in the city to improve security.

For now, these services are not intended to save the city money, but they can generate positive externalities by increasing a city's attractiveness, as much for its residents as for outsiders, e.g. tourists and investors.

6.5.2.4 Smart grid and metering

Smart grid technologies and the services associated with them consist mainly of adding "intelligence" to classic meter systems installed in homes and businesses[2]: chiefly electricity, gas and water.

Individual and shared meters have traditionally (and still do today in most countries) logged a home or a building's consumption, to then bill the energy contract customer.

The drawback of these systems is that a utility company employee needs to go to the customers' premises to read the meters. With the advent of new information and communication technologies, utility companies have access to new kinds of connected meters that allow them to perform readouts remotely.

Services

Little by little, these smart meters have become more intelligent and taken on a growing array of services. Today, they can perform several functions:

- Measure total consumption for a set time period;
- Provide the actual consumption figure for any given moment;
- Provide customers with advice on how to reduce their energy consumption;
- Detect electrical malfunctions (voltage problem, power outage);
- If applicable, manage the electricity produced by the home or building (powering the building from a local source, resale to the energy company, switching between the local and outside source…).

For the utility company, smart metering technologies enable far more detailed and accurate management, and bring a range of advantages to the entire distribution chain, as illustrated in the following example of smart grids.

[2] For the sake of simplicity, the term "flow" is used to refer to electricity, gas and water.

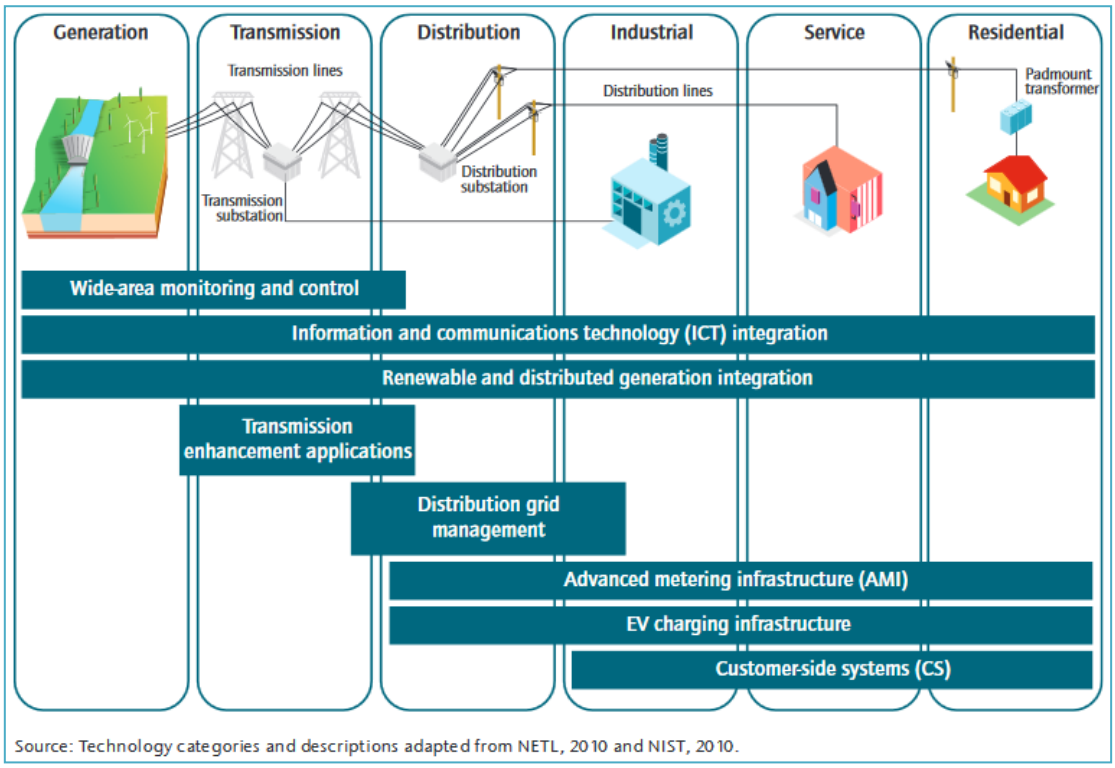


Figure 13: Functionalities enabled on the entire smart grid distribution chain [24]

Business models

Smart meters represent a sizeable cost for utility companies, but this cost is typically carried over to customers who pay for the new meters to be installed, whether they want it or not. Connectivity represents a relatively small cost, and is folded into the price of customers' subscription. The aim with smart meters is to enable customers to save on energy, and to reduce overall consumption thanks in particular (according to suppliers) to incentives to tailor consumption according to time of day: different rates are charged depending on the time of day and the season, to encourage users to spread their consumption out over time. All of these mechanisms allow customers, in theory, to generate savings by changing their habits. These savings are not automatic, however, and require the change to come from the customer. These savings would help amortise the cost of the smart meter installed by the utility company. To make full use of this new equipment, power companies need to either integrate a smart meter operating platform into their information system, or outsource the task to a service provider that will operate the meters and deliver the data collected by the network to the power company.

6.5.3 Impacts of IoT on Automotive business ecosystems

The impact of the IoT on the automotive business is dual, first with the development of connected car services, and ultimately with the transformation of the car itself into an autonomous vehicle.

6.5.3.1 Connected car services

The initial development of the IoT in the automotive industry relies in the embedding of IoT in the car to provide additional services.

Services

The main applications of connectivity in the automotive field are:

- **Telematics**: this combines the power of computers and computer systems with remote communications technologies (such as GPS, wireless or cellular) to obtain information about

remote automotive vehicles. Users can unlock their cars, check the status of batteries on electric cars, find the location of the car, or remotely activate the climate control system. It mainly relates to driver assistance services and also includes emergency call services.

- **Infotainment**: by definition, this information-based media content includes entertainment content. It also includes telematics and more advanced tools. It is increasingly related to the mobile Internet through mobile applications.

Other applications are also related to the connected car topic:

- **Emergency call**: this makes use of black-box hardware installed in vehicles to wirelessly send information on airbag deployment and impact sensors, together with GPS coordinates, to local emergency agencies. Numerous regulations on this have been introduced across the world. In Europe, "eCall" is a project of the European Commission designed to bring rapid assistance to motorists involved in a collision anywhere in the European Union. This service is often included in telematics packages.
- **Pay-as-you-drive (PAYD) insurance**: a type of insurance whereby the costs of motor insurance are dependent upon type of vehicle used, measured against time, distance travelled and place.
- **Security**: here this refers to the services provided in the case of car theft, through embedded vehicle-tracking systems, as provided by (luxury) car manufacturers.

Business models

The main issue regarding market take-off depends, as mentioned before, on user willingness to pay and, indirectly, the ability to provide relevant business models. Split charging, revenue management and billing capabilities should enable the adoption of innovative new business models that reshape the value chain for the delivery of these new services. The idea of a split-billing system is to split the connectivity charges for separate services occurring in the same car, so that consumer apps – such as navigation and entertainment – can be billed to consumers, while connectivity for car diagnostics, vehicle telematics and safety services may be included in a manufacturer's subscription charge.

In the case of embedded systems (one SIM card and different subscriptions), innovative business models need to be found. Indeed, the viability of extending embedded systems for infotainment and navigation services depends in part on the ability to:

- Differentiate charging and split billing for service beneficiaries such as the manufacturer or the driver
- Manage multiple revenue streams across value chain players so as to improve the business case of connected-car services through the application of innovative business models.

As the connected-car market is evolving, many business models are still at the discussion phase.

Table 2: Main differences by implementation technique [25]

	Embedded system	**Tethered system**	**Smartphone integration system**
Applications	Telematics Basic infotainment	Mobile Internet mainly	Voice calls and SMS
Traffic	Predictable	Unpredictable (potentially very heavy)	Limited
Driver	Regulation in Europe	Connectivity costs for manufacturer	User accommodation
Business model for connectivity	B2B2C B2C (AT&T in USA)	B2C	B2C
Manufacturer involvement	High	Platform side only	Limited (user interface only)

However, many manufacturers are already using a combination of these implementation techniques, especially the smartphone integration technique for voice calls and SMS whereby people still dial a phone number and not the MS-ISDN attached to the vehicle SIM card.

Foreseen evolution

Ultimately, there is an opportunity here for a fundamental shift from a largely capex-based model to a more OPEX-oriented one, even potentially shifting the focus of the manufacturer's core business to embrace a new focus on car-based products and services. Once connected, car manufacturers could provide even more value-added services and change their business model.

As automotive is one of the most promising industries that manage large amounts of data, **data monetisation** of the connected car is becoming the prime opportunity for car manufacturers. The analysis of data regarding customer expectations and driving experiences could deliver new services, optimising the customer relationship. For instance, drivers could resell car-generated data to insurance companies, to benefit from a 'pay-as-you drive' insurance model, which may generate overall higher margins to insurers. Car manufacturers are already involved in financial services through guarantees, insurance and banking. Predictive maintenance adds further value by reducing overall maintenance costs and enhancing car performance.

6.5.3.2 Autonomous car toward the car as a service

Self-driving cars, also known as 'autonomous cars', are generally defined as any car capable of fulfilling the operational and tactical functions of a traditional car with limited or no human intervention. More specifically, more than steering, braking, accelerating, monitoring the vehicle and driving environment (operational), a fully autonomous car could act as if it was a human to perceive and respond to events and determine driving tasks such as lane keeping or turning (tactical).

The main trend here is the automobile industry's revenue model will see a significant shift from absolute purchase to a subscription-type model.

Servicisation has major benefits as it provides

- Higher margin, compared with pure (one-shot) product sale
- More recurring and scheduled revenues

The automobile industry is transforming itself in terms of vehicle ownership patterns. The rate of car ownership is still very high in developed countries. In detail - for the figures are more impressive - in 2015, around 81% of households in France owned at least one car.

The initial deployments of autonomous cars are not fundamentally transforming the business model of car manufacturers. However, they have the power to enable and accelerate the transformation of the car industry business model from a product to a service offering.

Leasing

The percentage of cars leased has risen over the past several years, driven in part by growth in the segment of consumers who want the latest in-vehicle and connected-technology experiences.

This movement is strongly related to the SaaS model that occurs widely in the enterprise world.

Indeed, these companies are shifting their investments in depreciating on-premise installations over to subscription models that are more flexible and allow them to benefit from the latest technological advances and features.

Many factors drive the leasing concept, including:

- Vehicle substitution;
- Warranty and maintenance inclusion;
- No upfront cost.

Additional figures in terms of adoption also illustrate this trend. Indeed, BMW claims leased passenger cars represent 47% of its total sales of new cars in France in 2016.

Still in France, 36% of new car registrations resulted from a lease with purchase option or long-term lease, according to the latest industry figures for 2015. This proportion has doubled in four years.

The acquisition of a small car is perceived as a utilitarian approach. Indeed, it is affordable to purchase and less expensive to maintain, but its value depreciates more rapidly.

Conversely, a sedan, priced above 30,000 EUR, is seen as an investment. Its value tends to stay preserved over the long term.

According to a survey conducted by the ACA, a classic urban-type car has an annual cost on average 5,796 EUR in 2015, amounting to a purchase estimated between 10,000 and 15,000 EUR.

No costs up front

In the traditional model of vehicle acquisition, most people need to contract a loan. Automotive credit is, in most cases, the second largest spend in a given household budget, the '#1' being real estate credit. With the advent of car-as-a-service (CaaS), car hire will be less expensive from the user perspective, especially on a depreciating asset which is, on average, the opposite to real estate.

Vehicle substitution

In the CaaS paradigm, the user will be able to change their vehicle whenever they want, depending on usage.

Indeed, the user will not have to pay the maintenance, gas and upfront costs for an expensive SUV all the time whereas they only need it to drive it for camping twice during the summer and for a few days in the winter.

The main issue, however, is whether the concept can be practiced on a broad scale, meaning that everybody will book the same vehicles for the same time during the same period, leading to higher rates – following the supply and demand principle.

No warranty and maintenance

With CaaS will also come the SLA option. Indeed, in addition to the absence of upfront costs, the user will not see the major underlying cost of the maintenance operation.

Car sharing

The shared-car services introduced by Uber and Lyft are leading a trend to purchase mobility services instead of owning the means of transportation. In general, CaaS includes a variety of options for customers as described below, allowing them to choose the vehicles and itineraries that best suit their demands for different occasions.

- **Chauffeured personal journey**: customers can hail a driver (who is the car owner) to share a ride;
- **On-demand mobility service:** car hire service allowing car pick-up and drop-off at agreed places;
- **Car-pooling**: a number of customers share a ride to reach destinations through coordinated routes organised by certain algorithms.

Through mobile apps, these services collect the non-identifiable personal information, location and trip data. Combined with real-time traffic data and information from participating drivers, CaaS differentiates itself from regular mobility services of the likes of a taxi by dynamic rerouting and pricing, which have more time- and cost savings for users.

Apart from independent players like Uber and other companies that provide a platform that connects car drivers with customers, car-sharing services have also lured major manufacturers including GM, Volkswagen, Daimler and BMW.

6.5.4 Impacts of IoT on Agriculture business ecosystems

The digital age is transforming the production capabilities of all industries, including the agricultural domain. The development of connectivity aspect is the cornerstone of this transformation and IoT a key enabling technology that is increasingly part of agricultural equipment.

6.5.4.1 Context: Toward Agriculture 4.0

The IoT is seen as a transforming force that will modify not only production infrastructures, but also the development of products and services and even the customer relationship.

The trend is building on an array of digital technologies: Internet of Things but also Big Data, Artificial Intelligence, and of digital practices: cooperation, mobility, open innovation.

Applied to the agricultural industry this implies a transformation of the production infrastructures: connected farms, new production equipment: connected tractors and machines. These new processes enable both an increased productivity and increased in quality and environmental protection.

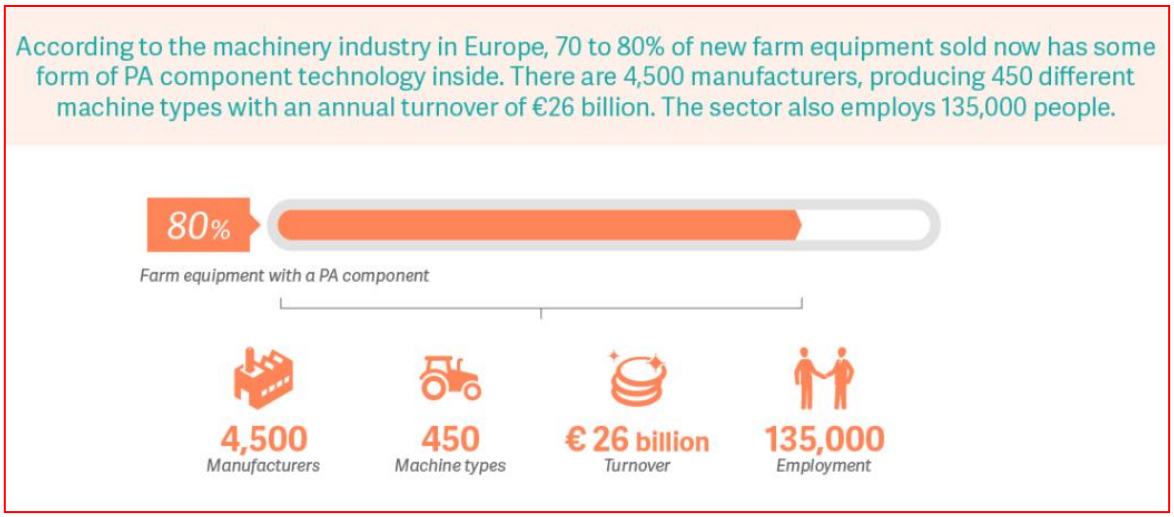


Figure 14: Farm equipment technology

But it also implies modifications in the value chain and business models with more emphasis on knowledge gathering, analysis and exchange.

Transformation of the production methods and tools

The digitalization of agriculture is based for a significant on the development and introduction of new tools and machines in production.

Connected tractors

The tractor and implement are key artefact of the development of the agricultural industry. Connectivity and localization technologies (GPS) are enabling several optimizations in the use of these agricultural tools.

This includes route optimization and drivers assistance, but also the deployment of sensors on implements to enable precision agriculture[1].

Furthermore, connectivity is also enabling business models evolutions with more precise tracking of usage of equipment and thus more precise billing of equipment use by contractors[2].

Automation

Another important transformation in the agricultural production process is the rising role of automation that increases productivity by reducing the need for human workforce.

This can take several forms, from the automation of vehicles, to the development of task specific robots[4] that automate parts of the production process.

New measurement tools

Finally, a key transformation resides in the ability to collect more data and measurement about the production processes.

Here also this ability take several forms from sensors deployed on tractors and implements to direct deployment of sensors in the field and soil or to the use of UAVs/drones or satellite imagery to collect measurements from above.

IoT requirements

The development of these new tools and practices in agriculture relies strongly on the development of connected objects and the Internet of Things. Yet the domain has specific requirements in term of connectivity.

Covering rural areas

A key requirement is of course the ability of communication network and solutions to deploy and cover efficiently rural areas.

This can have several implications: the development of solution to function with intermittent connectivity, the possibility of using 2G and LPWA networks or the necessity to wait for the deployment of new generations of networks (5G) to address some applications. Additionally, to be able to deploy efficiently in rural areas, IoT solutions also need to be able to withstand the specificities of the environment (limited access to power, dust, rain, vibration, etc.…). When not taken into account these factors can significantly delay the technology adoption.

Dealing with legacy technology

Another import requirement of the agricultural industry is the ability of IoT systems to deal and interact with legacy technology.

Although most agricultural equipment sold nowadays integrate digital capabilities, most of the fleet remains pre-digital tractors, implements and machines that will take a long time to replace.

The lifespan of agricultural technologies largely outplays the lifespan of communication technologies.

As example, the average age of tractors in Germany is 27.5 years (much longer than traditional vehicles), mainly due to high purchasing costs. It is thus important that innovations are able to deploy on existing machines.

Plug and play solutions that deploy on top of traditional equipment are thus developed to facilitate their adoption.

6.5.4.2 Impacts on Business models and ecosystems

The development of the IoT in the agriculture domain is transforming the business ecosystems and opening up new room in the value chain and new revenue model opportunities.

Servicisation

One direct impact of the development of the IoT in the agricultural domain is the development of service offering using the connected object to provide additional services on top of existing equipment.

A key use case regarding agricultural equipment is predictive maintenance as sensor deployment enables the manufacturer to track the usage of the product, detect early on loss of performance and provide maintenance early on.

But connected objects are also enabling other type of services such as advises on production practices and timing, or forecasting and scheduling services. They reinforce the link between producers and equipment providers.

Finally, the IoT is also enabling more precise monitoring and billing of contractors for the operation of agricultural machineries.

Workers activities and habits can be tracked and optimized over time reducing expenses and fuel consumption.

Connected ecosystems

The IoT deployment in the agricultural industry create more complex value network, with potentially new actors in the value chain (such as connectivity providers) and new roles of service and application providers

Additionally, the development of precision agriculture is based for a significant part on the ability to collect and analyse data.

But to achieve significant result and optimize production, data often need to be gathered and confronted at a higher level than a single exploitation/farm. This implies the development of data exchange mechanisms.

The organization of these data exchanges is set to be a crucial spot in the value chain with the ability to generate knowledge from data and set up a business model of optimization services.

The rise of platforms

Similarly, to other industries, the agricultural industry sees the development of IoT platforms. The strategy of actors (often large players in the industry such as equipment manufacturers of crop providers) is to establish themselves in a dominant position through both technological and data platforms.

The role of technology platform, centred on the control of technological enablers, can be important in setting up standards and securing the market early on. But most of the value is set to be found in the case of the agricultural domain in the control of data.

By taking control of the data set, and providing services that enable an optimization of production process, industrial actors can secure a strong position with both strong barriers to entry and recurring revenues. This trend is set to reinforce the captivity of farmers to industrial actors.

6.5.5 Impacts of IoT on Wearables business ecosystems

For wearable providers, the core business model is mainly based on the sale of the hardware product in a ‘one-shot sale’.

Nevertheless, it is expected that business models are likely to evolve in the near future as providers may reuse or sell the data generated by the objects to other companies.

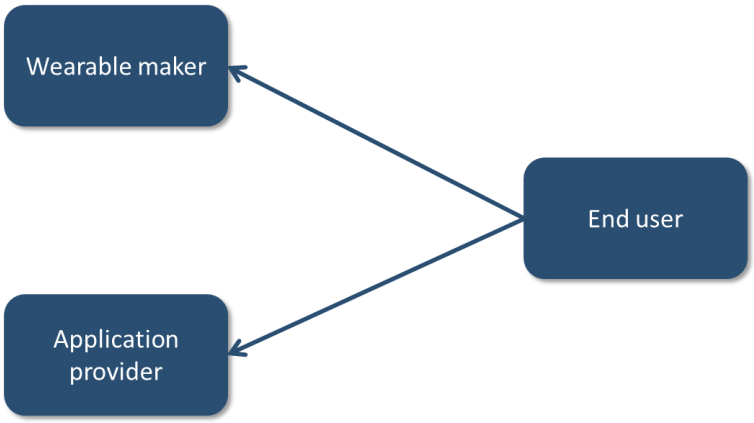
Whether this shift occurs rapidly or not will depend on the nature of the data produced by the object, and whether they relate to personal data or not.

6.5.5.1 Current business models

As mentioned previously, the main business model is based on product purchase for now.

Source: IDATE, in *Wearables and its verticals*, December 2014

Figure 15: Business model for smart wearable



Source: IDATE, in *Wearables and its verticals*, December 2014

Figure 16: Business model for fitness objects

6.5.5.2 Future expected business models

Market adoption rates are still low for the wearable market and, unless there are any significant changes, this is likely to remain a niche market in the short, and even the medium, term.

To overcome this, a shift in business model needs to be found. It requires a virtuous circle in which the trigger could be lower prices. This would lead towards higher adoption, meaning higher unit sales and thus lower price through economies of scale and similar factors.

Source: IDATE, in *Wearables and its verticals*, December 2014

Figure 17: Virtuous circle for high adoption level

Telco involvement

For some industry players, the relative success of smart watch adoption (in terms of modest shipments) is due to the absence of end-to-end connectivity.

Some players are considering whether to embed cellular connectivity in the smart watch.

One major hurdle is the willingness of the smart watch owner to pay for connectivity while at the same time already having a smartphone.

Non subsidy-based model

Nevertheless, telcos are pretty confident of selling connectivity to the smart watch, in principle. No pricing scheme has ever been unveiled but the introduction of a smart wearable into a share plan could be an interesting trade-off, as the device does not consume too much.

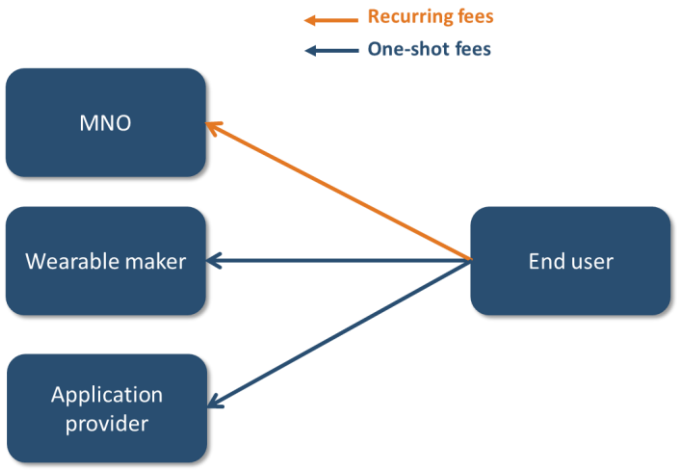


Figure 18: Non subsidiary based model[26]

Hence, an end user would be willing to pay 10 USD to integrate his device into his share plan as they could for their car now.

Subsidies-based model

Here, two models could be considered:

- Traditional model: the device is subsidised (even provided for free), as with connected devices such as tablets and smartphones.
- M2M model where the connectivity is included with the product purchase.

Traditional subsidised-model

In the model, the end user contracts directly with the MNO and pays an extra fee in addition to their monthly subscription and receives the device in exchange (for free, or with a heavy discount).

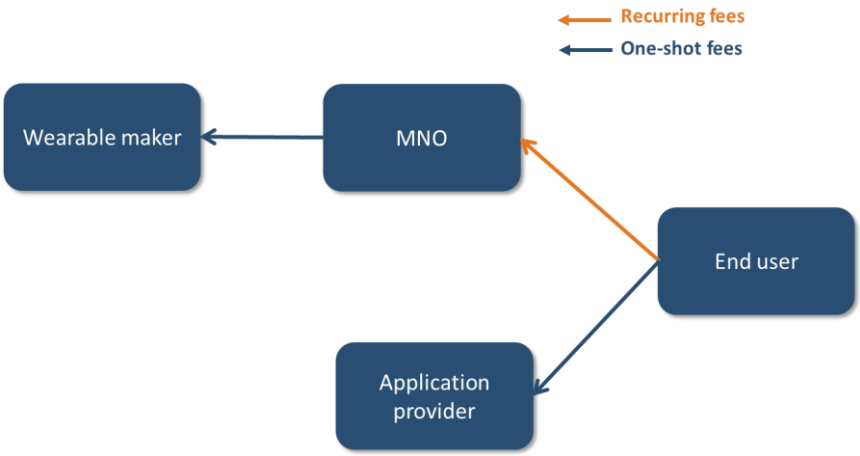


Figure 19: Model implying a wearables product subsidy[26]

M2M model

This model refers to the Kindle model whereby the end user does not have to contract any subscription to any MNO. Connectivity is included at the time of device purchase.

Unlike the first model, the M2M model is already a reality on wearable objects

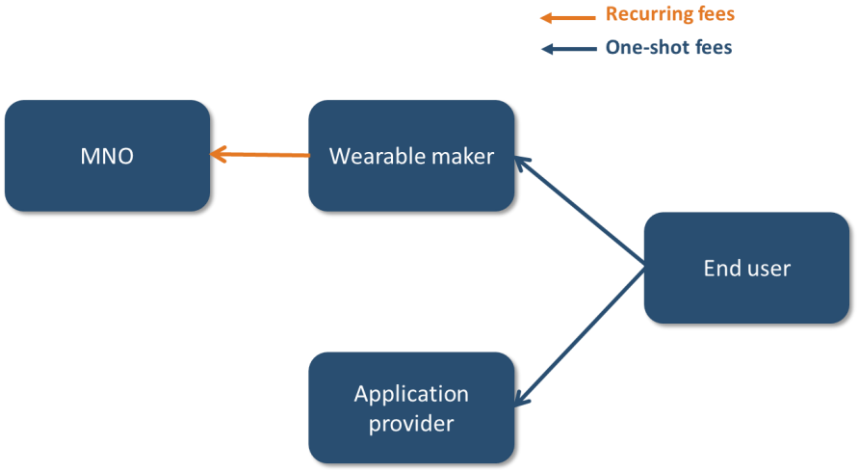


Figure 20: Business model implying a connectivity subsidy[26]

The main example is the Timex-AT&T partnership where there is one-year connectivity included in the smart watch purchase. After one year of use, the end user will be required to subscribe directly with AT&T.

Data resale: the next big thing?

The majority of connected products are not cellularly connected but mainly through PAN technologies (Bluetooth and Wi-Fi). Hence, the subsidised model is not relevant here. A second business model should be considered, and this could be data monetisation. This could be achieved either on the product itself or on the cloud side.

On product side

The main model would be based on the resale of data generated by the objects.

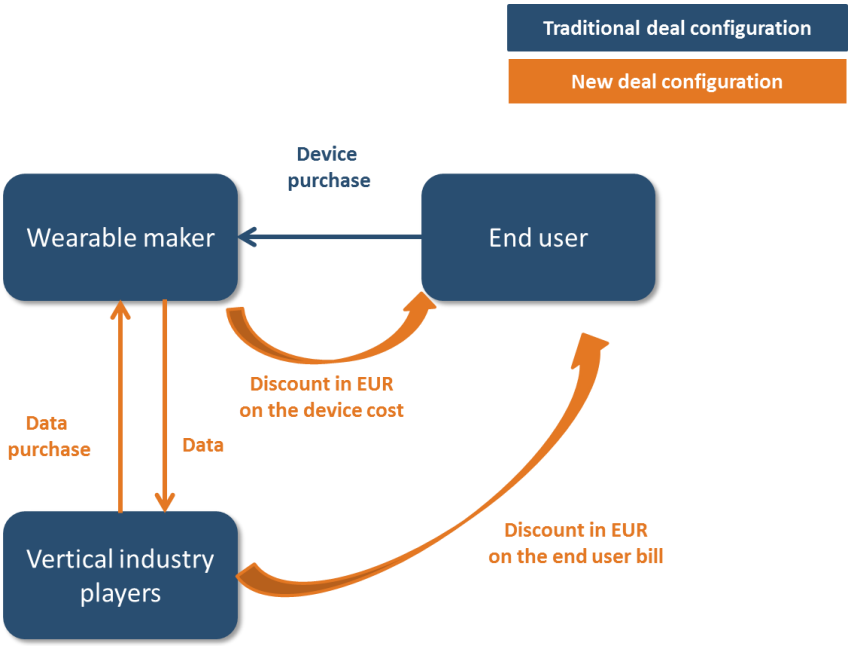


Figure 21: Data resale business model [26]

In exchange for this data, the end user could be allowed to receive several discounts for use on the following:

- The device cost itself.

- The consumer bill from a vertical player. The main players interested by this system so far are chiefly insurance companies and power companies. Several other industries could be interested by the data generated.
- Other alternative services and products.

Even though the revenue opportunities are likely to grow rapidly, data resale revenues will probably remain low regarding the global revenue for digital content. Data resale or data monetisation does not seem to be for now but data exchange is already a reality. Indeed, insurance companies have already pioneered in this space by launching some offers focused on wearable uses. One of the most advanced services comes from Discovery, based in South Africa. In France, Axa has also a deal with Withings.

On the cloud side

The monetisation of data could also be completed on the cloud side.

IT players receive 'tons' of data generated by billions of objects they can analyse (through analytics tools), process, combine and even cross-combine through big data techniques.

The goal is to generate new data based on the collected data and build new applications and services they can then monetise obviously. This allows the generation of new revenue which based more on services and less on products alone. Indeed, the module brings a new value to the object, with data which is monetisable. Moreover, wearables companies or third-party companies can therefore transition to new business models such subscription-based ones with, for example, coaching services on top of fitness products. As for traditional Web services, they also could develop advertising and marketing services.

6.5.6 Impacts of IoT on Health business ecosystems

Connected healthcare, where technologies and care converge into new products and services, has been placed great expectations to transform healthcare delivery and costs. **Remote monitoring and home care** is at centre among others, as cutting down the care expenses, chronic disease management, as well as flexible and efficient care delivery are of top priority to the industries. Traditional telemedicine such as virtual visits are on the rise in the US, where the social security systems is quite different from those in Europe. Caregivers are demonstrating interest in **connected medical equipment,** which is necessary to develop remote monitoring services.

6.5.6.1 Value chain

Across the value chain of connected healthcare, data is the core issue since data silo and security concerns are historically a severe challenge to highly regulated health industries. It is, though, connected devices and services which hold more potential to generate value by developing and selling "new generations" of sensors for both caregivers and patients, and by providing new business around emerging services such as telemedicine, remote monitoring and home-care delivery respectively. The reduction of readmission and overall care costs, and the optimisation of the care path and efficiency are also of great interest to health industries.

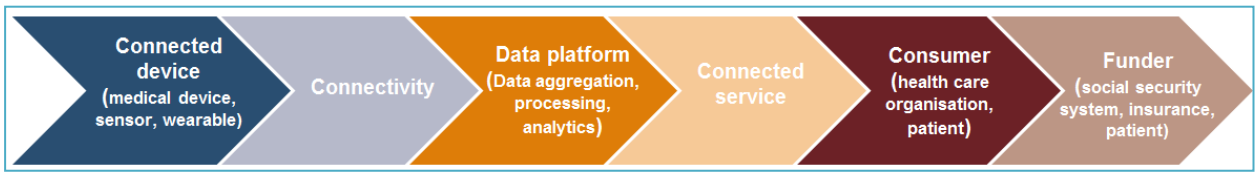


Figure 22: Healthcare value chain[27]

Where connected healthcare differs from other connected markets is that there is **a general consensus that end user/patients are not supposed to be the main body** to be charged for

connected healthcare solutions, although this situation may vary by country or region. In this respect, the funder plays an essential role in propelling the market's progress.

6.5.6.2 Services

Telemedicine and remote monitoring

Telemedicine, also known as "telehealth" and "e-health", is the use of information and communication technology to improve clinical health status remotely. Telemedicine was originally an umbrella term encompassing technological methods to connect patients with doctors, such as email, two-way video, smart phones and other forms of telecommunication technologies. Today, telemedicine has a wider definition of remote healthcare, generally covering these three aspects:

Consultation

It refers to virtual visits through phone calls or video conference, allowing patients to stay at home or in a normal living environments while still within reach of physicians. Such service mainly emphasizes time-related and access issues (such as making an appointment and long waiting times). These are a major concern for people living in rural areas, alongside coping with emergencies occurring outside working hours.

Diagnosis

A more complex aspect is with clinical telemedicine "visits" by primary care physicians and specialists who remotely gather the evidence needed to make an accurate diagnosis (also known as workup). In such cases, connected medical devices at a distance are required to collect symptoms and basically allow the consumer to make a self-diagnosis, by following medical guidelines. The diagnosis reports can be sent to physicians manually or automatically in real time, or at configured intervals. This service is indispensable for the following telemedicine applications.

Remote monitoring

Based on existing doctor-patient relationships in most cases, remote monitoring primarily serves an aging population and those suffering from chronic diseases, enabling the monitoring of patients or suspected patients outside of conventional clinical settings. More specifically, two sub-categories are identified.

The first category encompasses monitoring of the health condition before diseases attack. Such applications might include a specific vital sign, such as blood glucose or heart ECG or a variety of indicators for homebound patients. For the patient, they can receive reminders to take their drugs, and track how their health conditions are evolving. For the primary care physicians and specialists, the overall picture of each patient presented by continuous monitoring provides clinical decision support. In addition, telemedicine will alert physicians in case of emergencies, which means a doctor need not keep an eye on all data 24/7. Instead, the system calls attention mostly to the abnormal, urgent or worsening conditions that need intervention at an early stage and thus help to improve the outcome and avoid complications.

The second category involves some particular situations, mostly around the discharge of patients from hospital (after surgery or a period of readmission), the case of an elderly patient with limited ability to travel to hospitals to get treatment, and rapid response to emergencies.

The major intended benefits are in observing the recovery, avoiding unnecessary hospitalisation and identifying the real emergencies, rather than waiting in full rooms of an emergency department (ED). In this category, home-care delivery teams are more often involved than in the first. In such cases, a monitoring or nursing call centre, and home-care service providers, are all considered part of telemedicine as well.

Healthcare applications and tools

The tools can be websites, software or mobile apps, which can be patient centric or healthcare professionals facing, and locations for usage vary widely as well - at hospitals, in clinics or at distance. The table below lists the main applications.

Table 3: Healthcare applications and tools [27]

Users	Single use	Integrated use	Health-centric social network
Patients	• Online or mobile resources to search for specific health topics (disease or health awareness or self-checking of symptoms) • Doctor review and rating • Examination and follow-up of health or medical records/tests	• Tools enabling communications between patients and physicians • Doctor searching and appointment registration • "Doctor-on-demand" service to seek home-care delivery	• Gamification-based apps that encourage users to meet health goals • Patient communities built around particular conditions or diseases
Healthcare professionals	• Schedule planning and practice management • Document and medical imaging files management	• Software or apps for collaboration among physicians, nursing team and other care providers on such tasks as patient tracking, checking beds status, schedule of discharge, prioritised task lists or patient referral) • Decision-support tools enabled by the insights of data aggregation and analytics	• Social network exclusively for health professionals to share medical opinions, knowledge, to seek advice and career opportunities

Applications for single use generally dedicate a single purpose for individual users, implying that it is not necessary to integrate it with other systems to enable the functions. In contrast, those for integrated use are usually linked with the healthcare systems and tailored to multiple end users: either between patients and caregivers, or among healthcare professionals. Some new business is emerging with the take-off of telemedicine services. The "doctor-on-demand" option, for example, as an intermediate, is changing the way that healthcare is delivered in an Uber-like mode; it helps patients to have caregivers come to the home for diagnosis or treatment. However, the financial sustainability of such a service could well be in doubt if reimbursement does not catch up. Social communities or forums of patients draw upon their mutual support and encouragement between them. On the side of healthcare professionals, there are dedicated networking platforms which, on the one hand, allow the exchange on healthcare knowledge and such topics as healthcare reform or politics (more meaningful for independent doctors) and, on the other, may remove doctors from the issues of medical liabilities when giving their medical opinions anonymously on some platforms, such as SERMO.

6.5.6.3 Business models challenges

Reimbursement coverage and model

Coverage policies are not yet defined for connected health. The types of services covered and their reimbursement compared to in-person services need to be defined. In addition, the question of business model, which lies primarily in reimbursement coverage and model, varies greatly between Europe and the US. In the US, telemedicine is gaining significant momentum in clinical permissibility. Telemedicine practices are permissible today in 41 states plus Washington DC, compared to one-third of the country in early 2013. Payer reimbursement is also on the upturn - 24 states and Washington DC mandated reimbursement for telemedicine services. In 2014, telecare reimbursements reached their highest level to date at 13.9 million USD. In contrast to

the US, the financing of connected healthcare solutions moves much more slowly in Europe. Although reimbursement of telemedicine solutions is requested by the majority of players of telemedicine today in France, including patient associations, there is, indeed, only one service supported by telemedicine - screening for diabetic retinopathy that is repayable by routine – this as of the beginning of 2016.

Repayment of the monitoring of certain chronic conditions will be defined across the whole year of 2016, as part of the experiment for outpatient services. However, the pricing model package still waits to be considered and explored. What is shared in common for different regions and countries is that, consumers are less willing to pay out-of-pocket for the expenses of new care solutions.

According to a national (US) survey by Rock Health in 2015, only 7% strongly agreed that they are willing to pay out-of-pocket for their healthcare expenses.

If the connected healthcare market counts on patients/consumers to pay, it reported, the inability to raise prices in a price-sensitive market and the high labour costs for highly trained healthcare personnel may lower unit margins, thereby deteriorating the global market value.

CAPEX / OPEX issues for caregivers

Besides health costs reduction, patient-oriented objectives are another promise that connected healthcare is supposed to have, including improving care outcomes, patient convenience and increasing patient engagement. However, there is thus far no consensus on the true value that can be achieved in practice.

A study published in the Journal of the American Medical Association shows that, for a number of common conditions, the accuracy of diagnoses and adherence to best practices for in-person care vary largely case-to-case among telemedicine providers. In some cases, patients will still require physical visits and diagnosis.

The uncertainty in outcome, on one hand, makes healthcare providers prudent in applying connected devices or service in their practices; on the other hand, it keeps funders (both social security system and private insurance) out of play to avoid losing money.

Apart from improving device and system reliability, some industry-wide policy or protocol(s) that increase guideline adherence for telemedicine and home-care solutions are required for defining the standard of connected care. As raised above, unproven value is an extensive brake on investment by hospitals and in new policy making.

Additionally, connected medical services that provide visual visits or management of a complex chronic condition require large investments (capex) of hospitals: physicians have to purchase new hardware and software, redesign their practices, purchase or upgrade EHRs, and reconfigure or add medical office staff.

Concerning operating costs (OPEX), the deployment of new devices and capabilities tends to intensify the pressure on the available budgets.

Deployment may introduce new recurring costs, including but not limited to connectivity costs (such as connectivity for simple medical connected devices), the cost of servicing them through, for example, battery replacement, and additional time for communication with patients, specialists, pharmacists, hospitals, home-care centres and therapists.

As true value and new payment models that support and facilitate these services have yet to be figured out, the return on such investment is not yet clear. As a reaction to this, some countries are prioritising investment in different connected care solutions.

For example, the UK has created an institute to calculate what it is worth (or not worth) to invest in for the healthcare sector. A significant added value must be proven in order to justify extra expenditures for new capabilities.

As IoT deployments have moved from proof of concepts to genuine production environments, we have seen IoT business models form that incorporate some or all the value models listed above.

These business models reflect the needs and maturity of a company becoming a digital company and as such change the way that IT will engage with IT suppliers. Two of these business models are highlighted in the sections that follow.

IoT Business Model 1.0

Under the IoT Business Model 1.0 scenario, businesses realize that they produce products that get delivered into their supply channel and that is the last that they see or know about them.

It is only when there is a fault or a maintenance issue that customers contact the manufacturers or the retailers that sold them the product. Beyond that, businesses have no insights into their customers.

This is one of the best and simplest business propositions for an IoT solution. Here, businesses are using IoT there is a fault or a maintenance issue that customers contact the manufacturers or the retailers that sold them the product.

In this case, businesses are using IoT sensors to create an asset track and trace (very similar to an RFID implementation back in the late 1990s). The IT requirements are simple and easy to fulfil. They include:

- Preferably running the IoT application on a cloud environment (a cloud environment is preferred but is not a prerequisite, as many of these businesses don't have much in the way of IT skills, and therefore a scalable, relatively inexpensive public cloud solution meets their business needs)
- An IP-based network so that the IoT sensor attached or embedded in the business' products can be enabled and monitored.
- A simple or rudimentary analytics platform to generate low-level reporting.
- Little or no need for systems integration or service support as these IoT applications are run on a cloud platform for a standalone business unit (There are very few IT suppliers in this business model.)

IoT Business Model 2.0

With the IoT Business Model 2.0 scenario, businesses have made commitments to both IoT solutions and a digital transformation strategy.

Here, businesses are looking for as much information about their products, customers, suppliers, and competition in real time or near real time. Business outcomes are created from a rich source of internal, external, and IoT-device-based measurements.

In this model, IT and the lines of businesses are engaged in a very different way compared with the first IoT business model. Here, the following characteristics have been observed:

- Communication networks play a critical role as sensors need to be connected in a variety of locations where connectivity isn't always available, nor is it always inexpensive.
- A robust cloud infrastructure is a core requirement. The cloud strategy will require the ability to process both private and public data onto a single platform. Data management will become another core requirement, given the variety of data sources that IT will have to ingest and present to an analytics engine.
- Complex analytics and cognitive/machine learning processes are required to seek outcomes that will drive business change.
- Back-end office (or ERP-like) systems must be connected to the analytics platforms to enable a feedback system for all the interested parties (customers, machines, cross-company departments, product suppliers, supply chains, logistics, etc.).

- Management and systems integration partners will be needed to help drive seamless cooperation of business outcomes across the company's complex ecosystem.

Finally, companies that embark on the IoT Business Model 2.0 are companies that have committed themselves to digital transformation.

They see and run every aspect of their business as a service and, as such, expect IT to be fully committed to this too.

Running IT as a service requires a very different asset-funding model (both internally and with IT suppliers) as IT becomes driven by an OPEX model and not CAPEX.

Openly sharing business outcomes with any business unit becomes a core value of IT while at the same time maintaining a highly securable data and information environment.

6.6 Testing and Validating the IoT Ecosystem in Practice: An initial Proposal of KPIs to measure the Impact of the IoT European Large-Scale Pilots Programme

The IoT Large Scale Pilots Programme will offer CREATE-IoT the possibility to analyse the actual functioning in practice of the European's IoT ecosystem and to test the large-scale IoT demonstrations designed and implemented by the five Large Scale Pilots projects through their use cases and along several focus areas and application domains.

This paragraph will introduce the general framework underpinning the proposed set of methodologies and KPIs and outline the main areas of testing and validation.

6.6.1 Overall methodological approach

To derive the appropriate list of KPIs and measure the impact of the IoT European Large Scale Pilots Programme, CREATE-IoT will follow a multi-step approach.

- It will first consider each LSPs project and carefully analyse its initial objectives as well as the actual achievements to date of each demonstration;
- It will then carefully review (and update, if necessary) CREATE-IoT's Task 01.02 on Common methodologies and KPIs to make sure it is fully adapted to the actual development and deployment of the LSPs and propose a detailed document structure of deliverable D01.04 Common methodology and KPIs for design testing and validation.
- Based on the two aforementioned steps, it will then develop a comprehensive methodology for acquiring the necessary information from the LSPs, identifying additional sources to obtain relevant insights on the LSPs and their background information;
- A list of areas and sub-areas of measurement will then be formalized (an initial proposal is outlined below) and, for each sub-area, a list of KPIs, together with their definition, description, calculation method and targets, will be finalized.

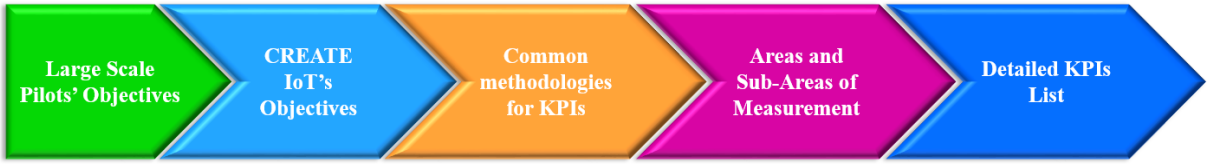


Figure 23: General framework for KPI generation

6.6.2 Proposed Areas and Sub-Areas of Measurement

At the time of writing, we have identified four main assessment areas corresponding to four key groups of factors affecting the implementation and performance of the Large-Scale Pilots projects.

- The **Innovation area,** assessing the level of innovation and positioning in the go-to-market process of the proposed IoT solution and/or demonstration;
- The **User Base and Market area**, describing the type of customers, users, markets and geographies targeted by each LSP, as well as the type of revenue and subscription models adopted by the suggested solutions and/or demonstrations;
- The **Feasibility and Sustainability area**, measuring the projects' level of development and their business and financial plan to ensure their sustainability in the years to come;
- The **Benefits and Impacts area**, apprehending the main benefits of the proposed IoT solutions and/or demonstrations for their direct users, their industries, as well as their impacts for the society as a whole.

Each area defined to measure the impact of the IoT European Large-Scale Pilots Programme will be segmented into thematic sub-areas aggregating a series of KPIs pertaining to an individual specific aspect of the overall IoT ecosystem.

Each indicator will be measured by submitting key representatives for each LSP a self-assessment tool consisting of a questionnaire covering all the areas and sub-areas mentioned above.

For each KPI an average score of the entire sample of respondents will be calculated and results will be aggregated in three evaluation classes corresponding to three different levels of assessment: low, medium and high.

The exact methodology underpinning the KPIs aggregation and calculation will be thoroughly detailed in deliverable D.01.04 Common methodology and KPIs for design testing and validation.

6.6.3 An initial list of KPIs

The four assessment areas and their corresponding sub-areas of aggregation are graphically presented below.

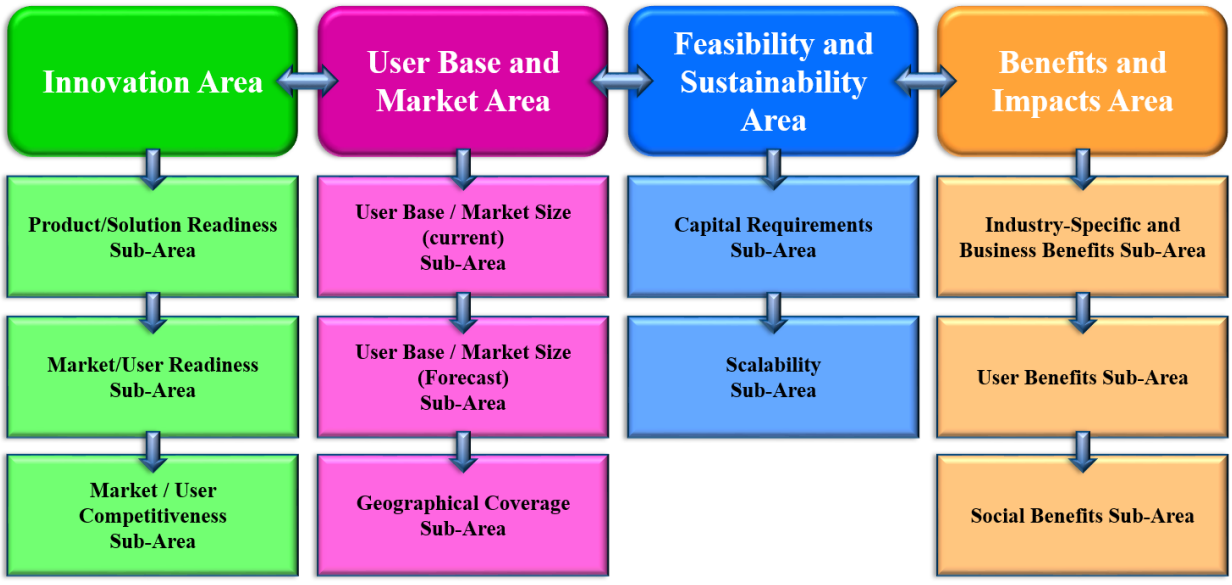


Figure 24: KPI assessment areas and their corresponding sub-areas of aggregation

As mentioned above, for each sub-area of assessment, a series of specific KPI's will be designed and calculated.

An initial example of indicators for each area and sub-area is presented in the right-hand column of the table below.

Table 4: KPI indicators for each area and sub-area

Main Area	Sub-Areas	Preliminary KPIs (indicative examples)
Innovation	Product/Solution readiness	Level of preparedness of solution and/demonstration, i.e. TRL (= Technology Readiness Level = or > than 6 ("Demonstrated in Operational Environment)
	Market/User readiness	Users' needs identification and analysis - level of analysis' completeness, i.e. ERL (Experience Readiness Level)
		Market gaps' identification and analysis - level of analysis completeness
		Solutions'/Demonstrations' value proposition - level of validation in the market, i.e. MRL (= Market Readiness Level = or > than 6 ("Demonstrated in Specific Market)
	Market/User competitiveness	Number of existing similar solutions/demonstrations in the EU
		Number of existing similar solutions/demonstrations in the outside the EU
User Base and Market	User Base / Market Size (Current)	Number of subscribers (current)
		Average subscription duration (current)
		Percentage Ratio subscription vs cancellation (current)
	User Base / Market Size (Forecast)	Number of subscribers (estimate)
		Average subscription duration (estimate)
		Percentage Ratio subscription vs cancellation (estimate)
	Geographical Coverage	Number of subscriber in the EU
		Share of subscriber by EU Member State on total number of subscribers
		Number of subscribers outside the EU
		Share of subscriber by country on total number of subscribers
Feasibility and Sustainability	Capital requirements	Amount of investment necessary to fund on-going growth after initial investment
	Scalability	Achievable increase in market size / user base in a given period of time (percentage)
Benefits and Impacts	Industry-Specific and Business Benefits	Reduction of operational costs in a given period of time (percentage)
		Enhancement of customer / user care or service in a given period of time
		Improvement of marketing and communication effectiveness in a given period of time
	User Benefits	Providing better quality of service to users
		Reducing/saving time to users
		Guaranteeing faster and easier access to information to users
	Social Benefits	Number of public community groups (elderly, children, families, minorities, disabled people, etc...) addressed;
		Number of private community groups (industry, SMEs, Service Providers, etc...) addressed;
		Number of national/European policy challenges addressed (transport policy; environmental policy; etc.)

7. SUMMARY

IoT has developed in the last years beyond the sum of seemingly fragmented and complex technologies merged together into a paradigm, which is bridging the physical world with the virtual world by combining augmented reality (AR), virtual reality (VR), machine learning and artificial intelligence (AI) to support the physical–digital integrations in the Internet of mobile things based on sensors/actuators, communication, analytics technologies, cyber–physical systems, software, cognitive systems and IoT platforms with multiple functionalities to address several of society's most pressing social, economic and business challenges.

The convergence of technology, business and societal macro trends such as network connectivity/IoT platforms security, data monetization, consumer expectations, the regulatory landscape support to speed IoT adoption and deliver measurable results across several industries and sectors.

7.1 Contribution to overall picture

This document provides the framework for collaboration and exchange of information among IoT European Large-Scale Pilots Programme projects and various IoT activities in Europe to support the delivery of IoT solutions of a global/common nature and scope. The document analyses the global IoT ecosystem and describe the exchange of information on best practices and approaches resulted from various IoT-FA activities and stakeholders under the activity groups in which the partners from the IoT large-scale pilot projects are involved.

In this context, the document presents the overview and strategy of IoT-FA and the activities and the stakeholders involved. The focus is on the presentation of the IoT European Large-Scale Pilots Programme projects with their objectives.

The cooperation mechanism introduced for partnering among the large-scale pilots is based on eight specific activity groups that share resources, capabilities, and competencies in pursuit of mutual interests for the advancement of common goals for the IoT European Large-Scale Pilots Programme. Each activity group concept and goal framework for collaboration and information exchange is described together with the objectives, collaboration plan, expected outcomes and impact of results for the whole programme.

In order to monitor the implementation of the strategy and coordination plan an IoT ecosystems analysis from both the users' and buyers' perspective is presented together with an analysis of the IoT policy issues, interoperability and standardization that are relevant for the IoT-FA activities.

The description of the industrial and societal challenges with an overview of IoT business models and the impacts of IoT on business ecosystems covered by the large-scale pilots (healthcare and aging well, smart farming, wearables, smart cites, automotive/autonomous driving) are introduced as important element of the IoT-FA strategy and coordination plan reference for implementation and monitoring.

7.2 Implementation and future activities

The IoT- FA strategy and plan aims at positioning Europe as a leading player at the global level in several industries, through joint advanced technological development and use of the IoT. This is realized by creating IoT ecosystems supported by open technologies and platforms to support the renewal of the industry and the public sector, increased collaboration between industries, and focused research and development in the common area of interest. This is supported by using the liaisons with other initiatives including contractual Public-Private-Partnerships (e.g. Big Data, Factories of the Future, 5G-infrastructure), Joint Technology Initiatives (e.g. ECSEL), European

Innovation Partnerships (e.g. on Smart Cities), and other Focus Areas (e.g. on Autonomous transport). The IoT-FA strategy and coordination plan document is laying the foundation for the next activities that are focusing on IoT road mapping by aligning key cross-functional IoT stakeholders, providing a tool to develop IoT research and innovation strategy and plan execution across various industrial sectors during a common period time. These strategic views of the IoT FA enable to identify potential shortfalls of growth goals and targets, and then make better, more informed decisions about the IoT focus areas, allocation and funding opportunities. By highlighting gaps in the European IoT research and innovation based on the new technology, business models and deployment results from the IoT projects and initiatives, road mapping yields valuable insights and increases European IoT ecosystems' agility when reacting to constantly changing IoT market, product, services and technology factors while formulating future strategy.

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