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IoT landscape and alignment with European IoT SRIA

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1. EXECUTIVE SUMMARY

Publishable summary

This document is presenting the IoT landscape in Europe and alignment with activities at the national and global level. The emerging wireless IoT technology pave the road for anything and anyone, to be connected online anywhere and anytime. The available bandwidth is increasing due to efficiency improvement of the communication technology. The sensors for data collection get smaller, and the power consumption and development costs are decreasing, at the same time power efficient data processing units increase their computing capacity. The scalability properties increase and opens enhanced big data collection supported by edge computing. These main key drivers behind the development of IoT, open for new markets through new interactions, solutions, services, and business models.

The IoT is now entering a critical phase in its market acceptance and deployment. The IoT adopters will be called to finally move beyond initial proof of concepts toward broader and forward-looking implementations, and the IoT players will be expected to consolidate their partnership strategies while developing stronger vertical specialization. Some of the key topics affecting the European IoT market scenario are the continued importance of security with IoT, 5G driving the mobile IoT, the evolution of IoT platforms, artificial intelligence (AI) and edge computing integration, digital twins' representations, Blockchain and IoT, and data monetization and IoT-driven new business models. Coordination and alignment with the research and innovation agendas at the European level with the developments in the different European initiatives and align with the global trends are important, for example through 5G, ECSEL, ECSO, euRobotics, and FoF/EFFRA.

The major development trends in IoT application areas are identified. The demand and supply sides are analysed individually, together with market pull and technology push balancing, and common high-level considerations. The analyses are based on the EU strategic areas within automotive, health, smart cities, consumer IoT, manufacturing and energy, and linked to the ongoing large-scale projects AUTOPILOT, ACTIVAGE, SYNCHRONICITY, MONICA, IoF2020.

Concerning privacy and security issues, IoT reshapes the collection of data from an "active" feature of human-computer interaction to a "passive" one where devices communicate and exchange data among themselves. Such developments have important privacy and security implications that organizations involved in IoT-related projects must prioritize if they want to respond to the market needs. The General European Data Protection Regulation (GDPR) empowers data subjects for their protection of personal data by granting them a set of rights. EU aim to get in place a "digital-friendly" regulatory framework and has put forward several initiatives to complete the Digitising European Industry (DEI) initiative. Some of the most relevant key impact on the European industry are proposals on cybersecurity and free flow of non-personal data. Relations between online platforms, businesses, and liability challenges emerging from IoT and AI will be addressed.

Non-publishable information

This document is public.

2. INTRODUCTION

2.1 Purpose and target group

The purpose of this work is to give an overview of the IoT landscape and the alignment with the IoT activities at national and global level. Including market and development trends in IoT application areas. IoT for eHealth and ageing well, smart cities, consumer IoT, farming and smart agriculture, manufacturing, energy and smart home/buildings are given special attention together with IoT initiative across industrial sectors, and strategic and innovation agendas. The target groups are both the IoT premise providers, business developers, and industrial stakeholders within the different industry sectors and application domains.

2.2 Contributions of partners

Together with D01.01, D01.02, and D01.03, this deliverable (D01.05) is related to the work carried out in task T01.01 (IoT Focus Area coordination and road mapping). According to this task the contributions of the partners are described as follows:

SINTEF is the task T01.01 leader. SINTEF coordinates the activities and develop 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 ensures that the IoT roadmap helps to 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. Work 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 include the promotion for sharing of conclusions and road-mapping with similar activities in countries and regions outside Europe.

ATOS work 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.

IDC guarantee the 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 begins 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 provide an analysis of their key strengths and weaknesses. Subsequently, a restricted number of methodologies are 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 is chosen and adequately adjusted to respond to the specific needs and requirements of the IoT ecosystems under consideration in the present project. Works 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 will be directed at additional IoT initiatives in other mature and emerging markets outside Europe.

IDATE provides 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 is directly involved in the production of the roadmap, bringing together the technical and non-technical inputs and directing the edition process. IDATE contributes 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.

GRAD provides a liaison with the AIOTI vertical WGs, coordinating their contributions to a roadmap for the wide adoption of IoT in the corresponding sectors, at a European level. GRAD will also provide links with the task T02.02 for integrating the methodologies, best practices and business models' aspects learnt from the LSPs in the roadmap.

NUIG works 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. The main contribution is to guide in the direction of semantic interoperability vision and the definition and uptake of semantic methodologies for the IoT and help on bridging current ICT 30 projects activity with the LSP and in general continues building community through the contribution to support IoT focus activities.

AS supports the global road mapping activities with a focus on IoT and privacy.

2.3 Relations to other activities in the project

This deliverable is focusing on the IoT landscape in Europe and the alignment with activities at the national and global level, and is related to the work done in deliverable D01.02 (Evolution of IoT FA) which addressed the first step through the European IoT roadmap of research and innovation priorities [1]. Both deliverables are carried out within task T01.01 (IoT Focus Area coordination and road mapping), and the roadmap was acting as reference point for ongoing dialogue and action for the IoT FA.

Concerning privacy and security issues, the IoT policy legal frameworks worked out in WP05 (IoT Policy Framework - Trusted, Safe and Legal Environment for IoT) describing the main ingredients of the IoT policy framework, and the main regulatory and other legal ingredients of IoT, LSPs and similar IoT ecosystems have been used as background material [36][37]. The LSP handbook worked out in WP02 (IoT Large Scale Pilots Ecosystems Arena for Sharing Common Approaches) has been useful, for the IoT landscape overview particularly [5].

3. IoT LANDSCAPE OVERVIEW

3.1 IoT market trends and developments

The emerging wireless IoT technology pave the road for anything and anyone, to be connected online anywhere and anytime. The available bandwidth is increasing due to efficiency improvement of the communication technology. The sensors for data collection get smaller, and the power consumption and development costs are decreasing, at the same time power efficient data processing units increase their computing capacity. The scalability properties increase and opens enhanced big data collection supported by edge computing. Over the past 10 years, the cost of sensors has been dimidiated, we have gained 40 times as much bandwidth and 60 times as much processing power at the same costs [2]. These main key drivers behind the development of IoT, open for new markets through new interactions, solutions, services and business models.

The IoT is now entering a critical phase in its market acceptance and deployment. After several years of customers evaluating the case for an IoT solution, the vendors appear to be reaching a point in their products and capabilities that is now a viable business proposition. Those companies that seek to become digital natives through their work on digital transformation (DX) are seeing competitive advantages in their operating plans and the beginning of better customer experiences through IoT outcomes and services.

IoT market maturity evolution is now very much a reality, with more than 40% of European companies already using IoT solutions or currently developing IoT pilot projects [47]. European IoT spending is expected to reach €127 billion in 2018 and grow at a compound annual growth rate (CAGR) of 13% in the next four years [48]. IoT adopters will be called to finally move beyond initial proof of concepts (PoCs) toward broader and forward-looking implementations, and IoT players will be expected to consolidate their partnership strategies while developing stronger vertical specialization.

Some of the key topics affecting the European IoT Market Scenario in 2018 area

- The continued importance of security with IoT
- 5G driving the mobile IoT
- The evolution of IoT platforms
- Artificial Intelligence (AI) and IoT
- Edge Computing
- Data Monetization and IoT-driven New Business Models
- Digital twins
- Blockchain and IoT

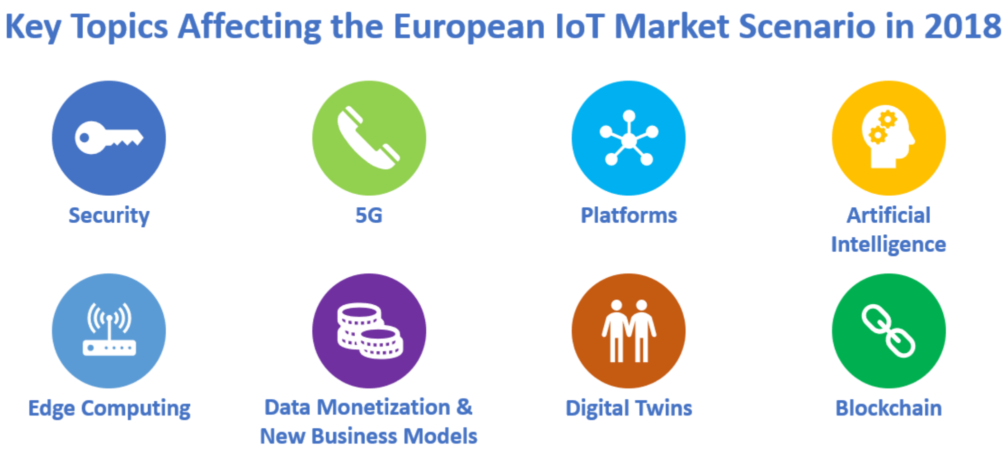


Figure 1: Key Topics Affecting the European IoT Market Scenario in 2018.

As the diverse IoT market reaches broad-based critical mass, innovative offerings in analytics software, cloud technologies, hardware components, and business and IT services have expanded rapidly. Understanding the key themes characterizing the market evolution is key to grab the new opportunities the IoT market offers.

Security & IoT: According to IDC European IoT Survey 2017 [22] 22% of European companies not adopting IoT cite security and privacy issues as the main reason for not yet implementing an IoT deployment within their organizations, confirming the need for guidance and reassurance from security vendors and partners on this theme. When looking at European IoT adopters instead, although only 1.4% of respondents with an active IoT deployment within their organizations did not have a defined security approach in place, 55% of them build security as they went along with the project or decided to make the project secure after the deployment [47].

Enterprise buyers that fail to hold IoT device manufacturers accountable for properly implementing physical antitampering and cybersecurity components in their products could end up absorbing costly, bolted-on cybersecurity improvements in the future. IoT enablement, which may involve connecting consumer-facing industrial control systems to the internet for the first time, exposes software vulnerabilities putting corporate data at risk, but also enabling attackers to target and potentially manipulate software-based safety mechanisms to cause intentional or unintentional physical harm to the public.

Security by design and embedded security is a must for organizations embarking on their IoT journey. As in all transformational projects, security is optimally done at the system design stage, but more likely (in deployed systems) at the time of connection to the Internet. As more use cases become available for reference, it will be easier for end users to plan for their IoT deployments and not be left trying to patch deployments when problems start to arise. Bringing together vendors in device security, connectivity, data, cloud, and application will help organizations with new opportunities for end-to-end IoT security solutions.

5G & IoT: Now that a detailed understanding is emerging of what 5G mobile will look like, it is becoming clear that 5G, like its predecessors, will have a crucial role in the maturity growth of Internet of Things, opening the door to some use cases that were unthinkable some years ago due to connectivity limitation.

While the current scale of IoT applications on mobile networks is still limited by the relatively small number of connected endpoints that a 4G cell site can support, 5G will be able to support up to one million connected devices per square kilometre. In addition to this higher density of connections per cell site, 5G will also expand the scope of IoT applications by improving further on the low power consumption characteristics of NB-IoT and LTE-M.

As well as connection density, 5G promises substantial improvements in two other areas of performance: higher data rates and capacity in the radio access network and much lower latency in the mobile network.

Although we will still have to wait a couple of years before a full commercial availability of 5G technologies, IoT applications will also benefit from a fundamentally different approach to network architecture in 5G. By virtualizing the functions of the network and orchestrating them on a carrier scale, operators will be able to create multiple instances of their networks, each one tailored to the needs of a specific application and/or customer. This concept, known as "network slicing," will be one of the key distinguishing characteristics of 5G networks [49].

Evolution of IoT Platforms: An IoT Platform is the hub in which applications, products, and services are readily available to end-users. The architecture of an IoT platform is diverse but most include device management, connectivity management, data management, visualization tools and dashboards [50]. After the initial IoT platform ecosystem and player explosion, some consolidation in the most solid platforms in the market is taking place, a trend that will lead to further merging of IoT platform players and a thinning out in the coming months. Two key features characterize

the third generation of IoT platforms' success in 2018: vertical specialization measured as an ability to tailor general frameworks to specific subindustries and use case requirements, and a rich capability in data gathering, mining, and advanced computing based on an open, integrated, and orchestrated ecosystem.

Today, the majority of IoT platform vendors offer a horizontal platform that developers can use to build a wide variety of IoT applications. While this broad brush-driven approach to platform as a service may have been enough for other development paradigms, the industry-specific, analytics-driven nature of IoT projects call for a more specialized model. Therefore, enterprises will begin to seek platform providers that understand their specific use cases in depth and can leverage that knowledge to help them get to market quickly.

Artificial Intelligence and IoT: While most of European adopters are still not actively using analytics as part of their IoT deployments, high expectations in terms of analytics impact on the IoT scenario are put in place for the months ahead. Analytics capabilities including basic to advanced forms such as artificial intelligence, are critical to driving value from IoT investments by allowing organizations to extract meaningful insights that uncover opportunities, risks, or issues in vast volumes of IoT data.

AI techniques are still in early stage use, although its potential and disrupting role when applied to IoT use cases is evident. The move towards AI is particularly pertinent since it provides potential for IoT solutions to learn autonomously from newly available data to draw conclusions and optimize recommended actions or forecasts, for example by being able to forecast likely equipment failures before they happen. Underpinning this progress is the steady improvement in computational power from better processors and graphics processing units, combined with increased investment in massive computing clusters, often accessed as cloud services.

The AI's characteristics to be self-learning, adaptive, iterative and contextual, augmenting and replacing human decision-making, make a new class of IoT use cases "computable", fostering the rise of new Internet of Things scenarios.

Edge Computing and IoT: Edge computing is the overall architecture or hub where part or all of the data processing is delivered in edge locations. Essentially it is an intermediate tier between the "core" (cloud or traditional datacentres) and the connected devices themselves. While the benefits in terms of time to value, latency, bandwidth constraints, and lack of connectivity are clear, in some specific industries and use cases 2018 will be key to understanding end users' reaction to this new paradigm.

Edge computing is already an IoT reality, with more than one fifth of European IoT users using it for analysing data in their IoT deployments [47], although there is still a long run to go before fully experiencing edge computing capabilities and benefits its evolution could lead to.

Now that multiple competitors are reshaping their IoT message around the "perfect" cloud-edge-core balance, end users need to consider a tiered approach to other technologies while prioritizing the most "edge-oriented use cases" in their respective sectors.

Data Monetization, New Business Models & IoT: IoT data monetization is the ability to convert IoT data assets from sensors and other connected devices into economic value and optimized performance. IoT is finally enabling organizations to extract data from all their physical and digital assets and processes, translating these insights into competitive advantages. IDC expects 40% of European IoT projects to create opportunities for new revenue streams and business optimization by monetizing data in a "privacy-by-design" fashion by 2021 [50].

In parallel, new business model concepts are frequently associated to the IoT scenario. New IoT-driven business models do not only mean reimagining traditional businesses adding new IoT-based features to existing products/services but also testing new selling models (e.g., as-a-service, self-replenishing, subscription) and/or entering completely new markets across industries. With more

than a quarter of European IoT adopters expected to use IoT to launch new business models in 2018 [50], end users will have to think beyond efficiency and optimization to assess their IoT data value while integrating them with other data sources.

Digital Twins and IoT: The term "digital twin" was coined by Defence Advanced Research Projects Agency (DARPA) decades ago, but it wasn't until the past 24 months as 3rd Platform technologies (cloud, mobile, big data/analytics, and social business) and innovation accelerators like IoT were increasingly adopted that the concept of applying visualization and simulation more broadly to the operations of a product or asset became more possible and widespread. Digital twins, or virtual representations, can be used for ideation and early stage design of products and assets; for development of those product/asset models among design, R&D, and engineering; and ultimately, operations of digital twins by engineering and service working in concert, leveraging IoT data. That is, using the IoT-enriched digital twin to track performance, usage, and quality, so any issues can be addressed quickly, any software or mechatronic updates can be simulated, and the customer experience with the product or asset will be continually optimal. Digital twins are the visual incarnation of IoT [49].

Its role and application are certainly key in the Manufacturing sector, especially in discrete manufacturing subindustries such as Automotive or Industrial Machinery Manufacturing, although it is rapidly becoming a hot topic in other field assets-oriented industries as well, such as Utilities and Oil and Gas, Resource Industries, Engineering, and Telecom.

Blockchain and IoT: IDC defines blockchain as a digital, distributed ledger of transactions or records. Distributed ledger technology (DLT) allows new transactions to be added to an existing chain of transactions using a secure digital signature. Exchanges of value are stored chronologically in an immutable system of records and are secured with a cryptographic technology that is so difficult to tamper with that trying to corrupt it is impractical. When a blockchain algorithm is deployed and a transaction is initiated, the data is hashed and packaged in blocks of information that are distributed among the network. Once the transaction is verified by a majority of the nodes, it is approved. This process is automated with smart contacts and repeats each time a transaction is initiated. The outcome is a growing linear "chain," where each block is linked to a previous block and can only be appended to the end of the chain. Accordingly, each block verifies the authenticity of the previous block. Comparing blockchain with traditional methods of recording transactions, the presence of single ledgers in the network is replaced by a distributed ledger, updated by participants, as it allows new transactions to be added to an existing chain of transactions, without the need for a central system, using a secure digital signature, and with high security standards guaranteed by the consensus model that validates information [51].

The need to register, in a highly secured way, all data transactions generated by the proliferation of IoT connected devices, creates a perfect match between Internet of Things and the rising Blockchain technology. The potential for IoT and Blockchain to work together is even stronger for specific IoT use cases, such as supply-chain tracking in manufacturing and retail or sensor-based grid energy exchange in utilities. IoT and Blockchain could bring an increased level of authenticity and security in data transaction recording and that is also the reason why IDC expects up to 10% of Pilot and Production Blockchain Distributed Ledgers to incorporate IoT sensors by 2020 [49].

There are several reliable actors out there analysing IoT trends, and Gartner is one of them. Gartner's top 10 strategy technology trends for 2018, underpin the digital platform and set the stage for business innovation, cover the three themes; Intelligent, Digital, and Mesh as illustrated in Figure 2 [3].

The combination of people, devices, content and services, Gartner calls the intelligent digital mesh, enabled by digital models, business platforms and an intelligent set of services to support the digital business [4]. The AI allows more dynamic, flexible and autonomous IoT systems, the

virtual (digital) world merge into the real (analogue) world creating cyber-physical systems, and the mesh connections between people, businesses, devices, content, and services.

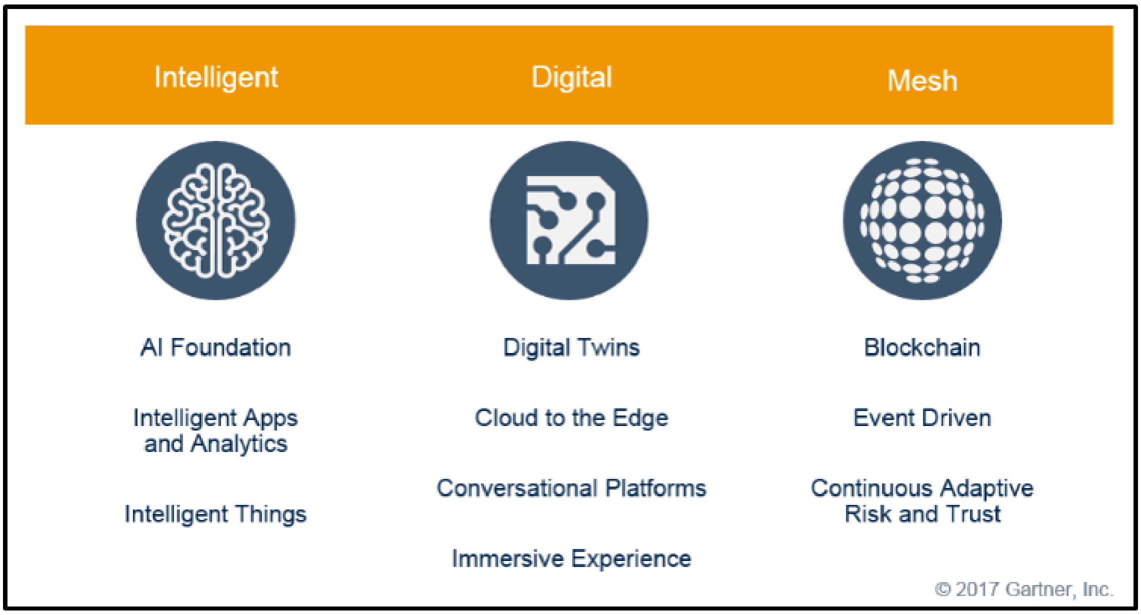


Figure 2: Top 10 strategic technology trends for 2018 (Source: Gartner [3]).

Intelligent: According to Gartner, the AI foundation will drive the payoff for digital initiatives until 2025, by enhanced decision making, reinvent business models and ecosystems, and remake the customer experience [4].

Every application and service will incorporate AI at some level of analytics in the next few years. AI is and will continue as the major battleground in a wide range of markets.

Intelligent things use AI and machine learning to interact with people, devices, or the environment in a more intelligent and autonomous way. Swarm intelligence (SI) is a concept that can be looked at as a subfield of AI and is based on collective behaviour and interaction of decentralized and self-organized systems [5].

Digital: Digital Twins are digital representations of real-world entities or systems, linked to real-world objects offering information on the state of the counterparts, respond to changes, improve operations and add value [4]. According to Gartner, digital twins will exist for billions of objects in the near future and offer help with asset management. Eventually offer value in operational efficiency and insights into how products are used and how they can be improved, and the potential for savings in maintenance repair and operation are huge.

Edge computing is a way to optimize cloud computing systems by using edge device computational capabilities to run analytic generation functions and thereby reducing the processes performed on the cloud [5]. Connectivity, latency, and bandwidth challenges plus greater functionality embedded at the edge favours distributed models [4]. To assume that cloud and edge computing are competing approaches are a misunderstanding, and the stakeholders should begin using edge design patterns in their infrastructure architectures.

Conversational platforms will drive a paradigm shift in translating between user and computer [4]. These systems are capable of simple answers to more complicated interactions but will continue to evolve to even more complex actions. The challenge is that the users must communicate in a very structured way. A primary differentiator among platforms will be the robustness of their conversational models and the API and event models used to access, invoke and orchestrate third-party services to deliver complex outcomes.

Augmented reality (AR) is the real-time view of the real physical world with the ability to add audio-visual effects, unlike virtual reality (VR) which replaces the real world with simulations [5].

Over the next five years the focus will be on mixed reality (MR) in combination with conversational platforms [4]. A fundamental shift in the user experience which is emerging as the immersive experience of choice, where the user interacts with digital and real-world objects while maintaining a presence in the physical world.

Mesh: According to Gartner, blockchain is a shared, distributed, decentralized and tokenized ledger that removes business friction by being independent of individual applications or participants [4]. It allows untrusted parties to exchange commercial transactions and have many potential applications besides financial opportunities. However, many blockchain technologies are immature, unproven, unregulated, and precautions and cryptographic skills are very important.

Digital businesses rely on the ability to sense and be ready to exploit new digital business moments, and the events reflect the discovery of notable states or state changes [4]. The most consequential business moments are those that have implications for multiple parties, different applications, etc. With IoT and AI, business events can be detected more quickly and analysed in greater detail. Gartner forecast that event-sourced, real-time situational awareness will be a required characteristic for 80% of digital business solutions, and 80% of new business ecosystems will require support for event processing by 2020.

The use of new technologies, business models, and sophisticated tools increases the threat potential. Security experts must apply a new approach [4]: Continuous adaptive risk and trust (CARTA), that allows for real-time, risk and trust-based decision making with adaptive responses to security. Traditional security techniques using ownership and control rather than trust will not work, these require embracing people-centric security and empowering developers to take responsibility for security measures are required.

3.2 Major development trends in IoT application areas

Another actor analysing IoT trends are IoT Analytics. IoT Analytics has analysed 1600 enterprise IoT projects and classified them according to ten IoT segments [6]. However, consumer IoT projects like Wearables and Smart Homes are not included in this analysis but have been in the loop for a relatively long time. Figure 3 summarize the results and shows the IoT segments according to global share of the enterprise IoT projects [6]. The details show the distribution between Europe, America, and Asia-Pacific (APAC) regions. The IoT segment trends are based on relative share comparison (and not the total number of IoT projects) with similar analysis in 2016. There is a predominance of Smart City projects located in Europe, Connected Health and Connected Car located in North America, and Smart Agriculture in the APAC region.

Most of the projects are identified in Smart City, most of these projects are in Europe, and the trend is increasing [6]. Smart traffic is the most widespread project application in Smart City, and include parking systems, traffic monitoring/control, bike sharing, smart bus lanes, smart ferry systems and smart bus shelters. Other project initiatives are linked to utilities, lighting, environmental monitoring and public safety.

The second largest segment is Connected Industry and the trend is decreasing [6]. This segment covers a wide range of applications both inside and outside the factory and has a strong project footprint in non-factory environments. Typical non-factory projects include asset monitoring and remote control of connected machinery (e.g. cranes, forklifts, drills, entire mines/oil fields). Other popular project application is within automation and control (smart factory), including holistic solutions (e.g. production floor monitoring, wearables on factory floor, automated quality control systems).

The third largest segment is Connected Building and the largest increasing trend since 2016 [6]. The most widespread project application is linked to facility automation to reduce energy costs.

Other popular applications are building security and heating, ventilation and air conditioning (HVAC).

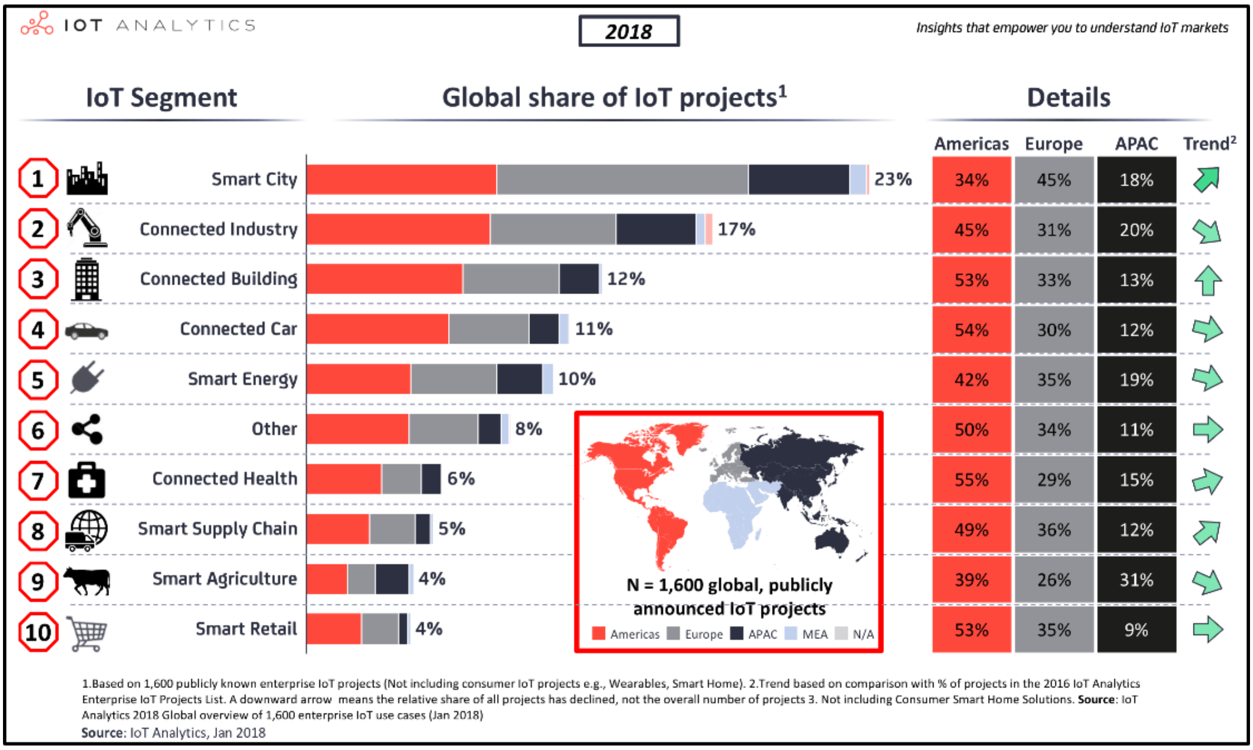


Figure 3: Ranking of enterprise IoT project segment 2018 (Source: IoT Analytics [6])

The next segment is Connected Car. The number of projects has more than doubled since 2016, but the trend shows that the relative share of all projects in the two analyses (2016 and 2018) has decreased [6]. The most widespread project applications are within vehicle diagnostics and fleet management solutions. The consecutive IoT segments, with less than 10% of the global share IoT projects, are Connected Health and Smart Supply Chain with an increasing trend, Smart Agriculture with a decreasing trend, and an unchanged Smart Retail segment.

The IoT European Large-Scale Pilots (LSPs) Programme includes the innovation consortia that are collaborating to foster the deployment of IoT solutions in Europe [7]. 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 LSPs addressing the IoT applications based on European relevance, technology readiness and socio-economic interest. The five LSPs projects: ACTIVAGE, AUTOPILOT, IoF2020, MONICA, and SYNCRONICITY are discussed below.

ACTIVAGE (Activating innovative IoT smart living environments for aging well) [8][9]: The project are breaking barriers for a sustainability active and healthy ageing through IoT technologies. The project use-cases are: Integrated care for chronic conditions; Cognitive stimulation; Prevention of social isolation; Exercise promotion; Monitoring inside/outside home; Emergency trigger; Safety, comfort and security at home; and Support for transportation/mobility. The use-cases cover applications mainly within the IoT segments Connected Health, but also Smart Home and Wearables. Even the Support for transportation/mobility use case may be touch a part of the Connected Car segment.

AUTOPILOT (Automated driving progressed by IoT) [8][10]: The project unlocking the potential of IoT to take autonomous driving to the next level. The project use-cases are: Automated valet parking; Highway pilot; platooning; Urban driving; and Car sharing. The use-cases cover applications mainly within the IoT segment Connected Car, but also Smart City.

IoF2020 (Internet of food and farm 2020) [8][11]: The project strengthens competitiveness of farming and food chains in Europe. The project has 19 use-cases in the following five trials: Arable; Dairy; Fruits; Vegetables; and Meat. The use-cases cover applications mainly within the IoT segment Smart Agriculture.

MONICA (Management of networked IoT wearables - very large-scale demonstration of cultural and societal applications) [8][12]: The project provides sound and security solutions for large open-air events in the smart city. The project use-cases are: Monitor/control sound levels; Monitor/manage crowd based on capacity; Detect/redirect high-risk queues; detect/report/handle security/health incidents; report/locate missing/found persons; Locate parent/guardian/staff members; and Event information. The use cases cover applications mainly within the IoT segments Smart City and Wearables, but even the Monitor/control sound level use case may be constituting a part of the Smart Health segment.

SYNCRONICITY (Single digital city market of Europe) [8][13]: The project is delivering an IoT-enabled digital single market for Europe and beyond. The project use-cases are: Human-centric traffic management; Multi-modal transportation; and Community suite. The use cases cover applications mainly within the IoT segment Smart City.

4. EUROPEAN AND GLOBAL IOT LANDSCAPE

This chapter provides an overview of the IoT landscape, especially focusing on the European context, but also covering all trends globally.

In order to do so, this section is structured so as to describe the following items:

- **Demand and supply side views**. For any landscape analysis and especially for IoT domain, it is crucial to analyse supply and demand individually and then consider the factors that can shift each other.
- **Balancing market pull and technology push**. On each domain of IoT in this analysis, identifying if it is either the marketplace requiring the solutions, or it is the technology and research the one driving is capital to understand it properly.
- Finally, **common high -level considerations** are introduced so as to close the loop and provide any additional and relevant information.

4.1 Demand and supply side views

In the first section, a domain-driven approach is considered. The following sectors are studied, in alignment with all LSP vertical domain and also introducing additional EU strategic areas, namely:

- IoT for **autonomous cars and autonomous driving**, covered by AUTOPILOT
- IoT for **eHealth and ageing well**, which is being investigated by ACTIVAGE
- IoT for **smart cities**, in alignment with SYNCHRONICITY.
- IoT for **consumer IoT**, which is the closest sector to MONICA activities.
- IoT for **farming and smart agriculture**, as in IoF2020
- IoT for **manufacturing**, as the sector is relevant in European research agendas.
- IoT for **rnergy and smart home/buildings**, being this also a strategic sector for the EC.

4.1.1 Automotive

The future transport sector will be characterized by increased digitalization, automation and electrification, and the automotive industry is no exception. Connected supply chain and improved manufacturing, Digital sources in the car buying process, Predictive maintenance, Autonomous driving, Mobility as a service (MaaS), and Data security and protection are digital transformation trends in the automotive industry [15]. The automotive industry is increasingly turning to new technologies, services and business models. More automated production lines maybe lead to less need for employees, but on the other hand the employees need to be educationally and technologically updated, and several new manufacturers, suppliers and other stakeholders are arising.

According to The European Automobile Manufacturers Association (ACEA), less mobility is not an option in the modern world, instead we need better mobility solutions [18]: (i) We need clean mobility that dramatically reduce automotive related emissions due to greater uptake of vehicles with the latest technologies and alternative powertrains, as well as intelligent transport systems and improved infrastructure; (ii) We need smart mobility manufacturers being providers of innovative mobility solutions, bringing the transportation landscape of private car, freight, bus, rail, pedestrian and bicycle traffic into a woven connected network, saving time and resources; and (iii) We need safe mobility though technological breakthrough including interaction between vehicles and the infrastructure, higher uptake of vehicles equipped with active safety systems, exchange of safety information, and autonomous driving (nine out of the accidents are due to human error) [18]. The European Automotive Telecom Alliance (EATA) comprises the European Automobile Manufacturers' Association (ACEA), and five other sectorial associations [19]: The European Association of Automotive Suppliers (CLEPA), European Telecommunication

Networks Operators' Association (ETNO), European Competitive Telecommunications Association (ECTA), GSMA Europe and GSA. Representing 38 leading European companies, these automotive and telecoms sectors working for accelerating technology implementation across borders and shore up connected and automated driving strategy.

The automotive industry is pushed hard by rapid changes in many segments. According to the EY's Global Automotive Centre; the automotive industry need to raise the five questions illustrated in Figure 4 in the preparation process for the future and assess how well they are prepared to respond to the opportunities and challenges these questions are presenting [17].

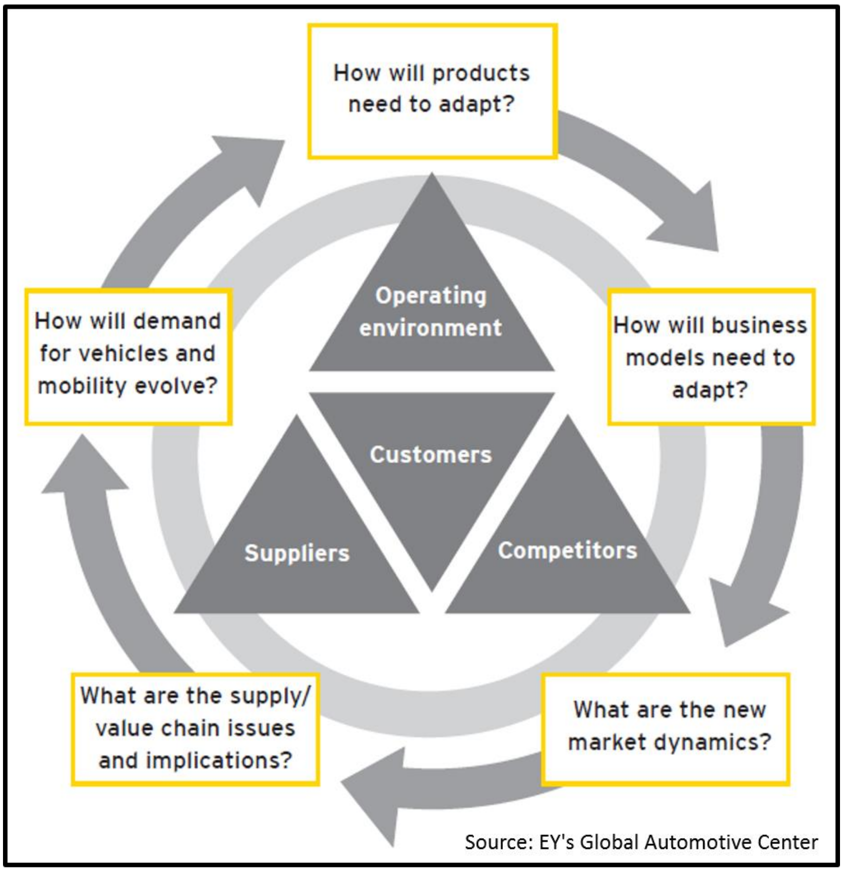


Figure 4: Stakeholder and strategic questions for the futures (Source: EY [17]).

EY's Global Automotive Centre has identified eight trends (reproduced below) that will impact the revenues, costs and profitability for the industry in a time with big rapid changes. These diverse trends are reproduced below and will influence the automotive industry on multiple fronts; ranging from social media phenomenon to structured government initiatives [17]:

- Governments push for safer and cleaner transportation.
- Original Equipment Manufacturers (OEMs) development new value propositions to meet shifting mobility needs.
- New players take the lead in the mobility market.
- Social media redefines automotive marketing.
- Collaboration among industry stakeholders.
- Portfolio rationalization among OEMs.
- New risks arise from the globalization of the industry.
- Recession and OEMs press Tier 2 and Tier 3 suppliers toward new strategies.

The AUTOPILOT project is representing the automotive domain, and working on automated driving progressed by IoT, with the objectives to increase safety, provide more comfort and create many new business opportunities for mobility services [10]. The IoT enabled autonomous driving cars are 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.

Through the IoT European Large-Scale Pilots Programme, AUTOPILOT, together with the other LSPs, contributes to strategic activity groups (AGs) that were defined by the LSP projects to foster coherent implementation of the different LSPs. The coordination is implemented by creating activity groups that address topics of common interest across the LSPs. Research and innovation efforts in specific IoT topics ensure the longer-term evolution of the IoT. In the first activity group (AG01) named "IoT Focus area sustainability", we have worked on development of common methodologies and key performance indicators (KPIs) to measure LSPs' impact throughout the duration of the European Programme. Another topic is analysing the different use-cases in the LSPs and identifying similarities, dissimilarities, and trends for common utilization for the community.

In section 3.2, we briefly introduced the different use-cases in the AUTOPILOT project. In line with the automotive industry regarding autonomous driving, the superior objective in these use-cases are to increase the safety and the automation level. According to SAE International road vehicle automation can be classified into six different levels as described in Table 1.

Table 1: SAE automation levels [14]

0	**1**	**2**	**3**	**4**	**5**
No Automation	**Driver assistance**	**Partial Automation**	**Conditional Automation**	**High Automation**	**Full Automation**
Human driver monitors the driving environment			Automated driving system monitors the driving environment		
Zero autonomy, the driver performs all driving tasks.	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.	Driver is a necessity but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

On the road to autonomous driverless vehicles, they become computers on wheels connected to the Internet and a variety of IoT devices making new features for the increasingly demanding consumers possible. The concept of Internet of Vehicles (IoV) or Vehicle-to-Everything (V2X) communications applied for autonomous transportation and mobility applications, requires creating mobile ecosystems based on trust, security and convenience to connectivity services and transportation applications to ensure security, mobility and convenience to consumer-centric transactions and services [16]. V2X covering vehicle to infrastructure (V2I), vehicle to pedestrian (V2P), vehicle to device (V2D) vehicle to grid (V2G) and vehicle to vehicle (V2V) as important communication building blocks of the IoT ecosystems.

4.1.2 Health

In Europe the rates of mortality have fallen significantly over the past decades [63] leading to considerable changes in the age distribution of societies [64] and according to the 2015 ageing report [65], underlying assumptions and projection, methodologies provided by the European commission, people aged 60 are now expected to live an additional 33% more (i.e. between 18 to 22 years) and with this it is evident why societies have now a higher number of older adults than children. By the year 2060 it is expected all around the world people will have this longevity levels, this is a transformation expected to continue and reach the age group of EU population of elders

(65+). Furthermore, one in three Europeans will be over 65 with a ratio of "working" to "inactive" population of 2 to 1, this representing a heavy impact on health and social care systems. Indeed, population ageing creates a common social and economic challenge for European countries as they must find ways to cover the cost with less economically active population.

One of the most accepted measurement scales in different studies in Europe and World Wide is the Clinical Frailty Scale, as shown in Figure 5. The frailty scale is a valid and clinically important construct that is recognizable by physicians and thus clinical judgments about frailty can yield useful predictive information. The 9-point Clinical Frailty Scale was generated by measuring frailty to 2305 elderly patients who participated in the Canadian Study of Health and Aging (CSHA). The frailty scale, since then has been used for determining the ability to predict death or need for institutional care and correlate results with those obtained from other established tools.

Figure 5. Clinical Frailty Scale (Source: Dalhousie University, Faculty of Medicine [66])

The EC has promoted the Active and Healthy Ageing initiative (AHA) and the objective is to increase the levels of quality and health promoting activity. This European initiative addresses the problem of the European population in process of ageing promoting the use of technology to make the process of ageing healthier, called citizen empowerment and incitation to self-equip is one of the explored options. ACTIVAGE is a H2020 program project that aims to prolong and support the independent living of older adults in their living environments and also responding to real needs of caregivers, service providers and public authorities, through the deployment of innovative and user-led large-scale pilots across nine Deployment Sites in seven European countries based on the IoT technologies. ACTIVAGE will concentrate on IoT solutions for older people classified under categories 1 to 5. For category 6 “Moderately frail”, the use of IoT solutions can positively impact the end users and their care network by preserving the independent living. ACTIVAGE focus is in deploying technology, mainly IoT-enabled solutions that work towards keeping older people away from category 6 and beyond, which already represents a significant cost in care for informal carers and for the formal healthcare systems.

The Active Ageing Index (AAI) classifies European countries according to four categories of indicators on Employment, Participation in Society, Independent Healthy and Secure Living and Capacity and enabling environment for active and healthy ageing (Figure 6). The objective for having this classification is to categorise positively, at individual level, dignity preservation, maintenance of quality of life, perception of better health, but also at the aggregated level as a population with expected benefits in terms of reducing the demographic and financial pressure of the healthcare systems, especially in European societies. The AAI report provides an analysis of the overall progress made in the period 2012 to 2015 as well as illustrating remaining opportunities for improvement, in the four areas of active ageing – employment, social participation, independent living and capacity for active ageing – across 28 countries of the European Union. Overall, the message of the analytical report is a positive one: on average, the national-level values of the AAI have increased during the period studied, in spite of the economic pressures faced across the region and the resulting austerity measures.

ACTIVAGE has been conceived as a unique opportunity to scale up Use Cases (UCs) that the demand sides consider strategic to improve ageing well of the target populations. The aim of the project is to align, set-up, deploy and measure relevant Use Cases that provide a value for the users

of the nine Deployment Sites across Spain, France, Italy, Germany, Greece, Finland and United Kingdom.

ACTIVAGE builds the first European interoperable and open IoT ecosystem, reusing and scaling up underlying open and proprietary IoT platforms, technologies and standards, needed to provide interoperability across heterogeneous IoT platforms that will enable the deployment and operation at large scale of Active and Healthy Ageing IoT based solutions and services.

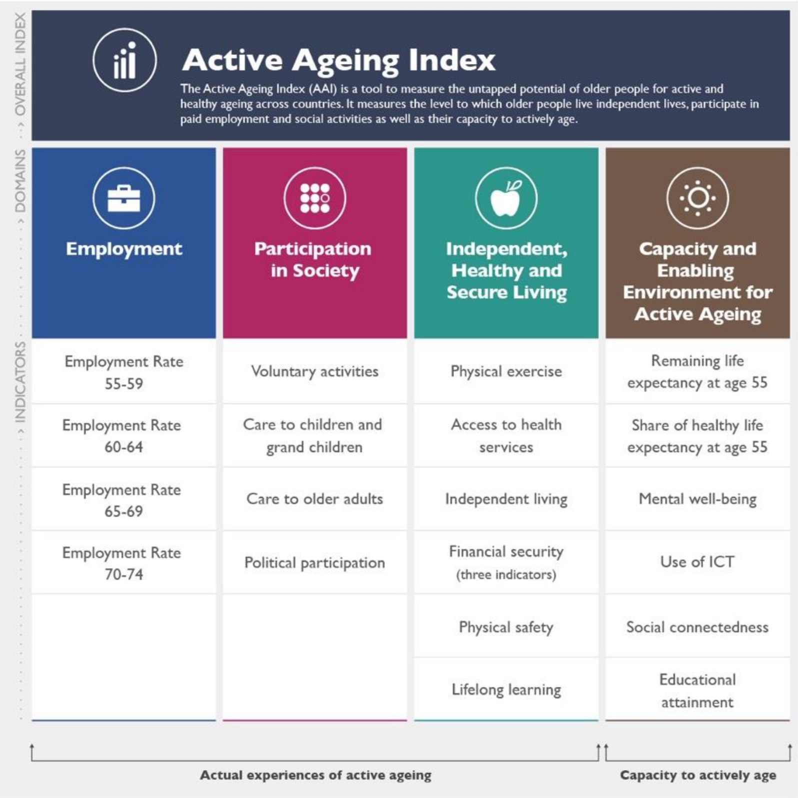


Figure 6: Active Ageing Index indicators and domains (source: UNECE-AAI project).

The project assesses the socio-economic impact, the benefits of IoT-based smart living environments in the quality of life and autonomy of older citizens, and in the sustainability of the health and social care systems, demonstrating the seamless capacity of integration and interoperability of the built 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.

Technical interoperability of IoT platforms, qualified Key Performance Indicators (KPIs), profitable and innovative business models, advanced service policies guidelines, appropriate regulatory framework, smart living services, implementation of nine large demonstrators, social innovation paradigms, for the ACTIVAGE project are not the final goals, but the basis to achieve the overall ACTIVAGE objective: the implementation a strategic reference sustainable ecosystem able to foster a strategic market growth of smart living solutions based on IoT and to promote quality of life of older people in Europe.

Such a reference framework will go beyond the actual project consortium composition attracting new members and reference sites within the so called “enlarged ACTIVAGE framework”.

Within ACTIVAGE, “Ageing Well with IoT” is considered as the goal to extend healthy living years of older adults living independently and autonomously in their preferred environments by the massive adoption of IoT solutions.

Figure 7: ACTIVAGE distribution on the basis of the 2014 overall AAI.

ACTIVAGE consortium has considered the reference of AAI for the selection of the geographical areas.

A total of four Deployment Sites are located in countries with low AAI (Spain, Greece), three DS are located in countries performing in average (Germany, Italy and France), and two with high performing countries in terms of active ageing (UK and Finland).

Concerning the European wide regions, all of them are represented in ACTIVAGE consortium: four Deployment Sites (DS) are located in the Mediterranean Region (Spain and Italy), one DS is located in the East Region (Greece), two DS in Continental Europe (France, Germany), one in Northern Countries (Finland) and one in Anglo-Saxon area.

The inclusion criteria for the selection of the ACTIVAGE Deployment Sites are a) Existence of a leading entity representing the demand side as a consortium partner, b) Demand side is already delivering services to end-users or have strong links with entities representing them, c) Existence of entities who supply innovative IoT solutions and/or basic technologies and have access to the insights/code of the solutions in order to be adapted to the ACTIVAGE interoperable framework, d) The members of the Deployment Site have a common background and experience in piloting the same or similar solutions, e) The ambition to scale-up a significant amount of end users in a sustainable way, f) The solutions to be tested have clear business models, as well as the relevant stakeholders to execute them, g) Solutions to be tested and validated must have a TRL 6 or 7 and get to TRL8 or 9 after the project ends, h) Entities representing the demand side must have well-defined strategies for sustainable continuation, depending on the achievement of local Key Performance Indicators; i) Openness to adopt new solutions to be selected according to local needs, j) The solution has to be deployed in a geographical area: private space, neighbourhood, city, region, or country. When several locations are proposed, they should have common interests in order to be considered as a site, k) Entities participating in the deployment site have been involved in EIP-AHA.

The analysis underlines the fact that every country analysed has room for improvement. Indeed, what makes the AAI such a valuable tool is its ability to pinpoint the specific areas where attention could be focused to make further gains. Denmark, for example – which is ranked second overall among the 28 countries analysed, and which takes first, second and third place in the domains of independent living, capacity for active ageing and employment, respectively – reaches only tenth place when it comes to participation of older persons in society. The analytical report shows how

the AAI can serve as an instrument for suggesting innovative policies to further countries' efforts at fostering active and healthy ageing. While it is impossible at this stage to prove how far any given changes are the result of any specific policy or programme, continued inter- and intra-national research will be able to investigate such questions more concretely.

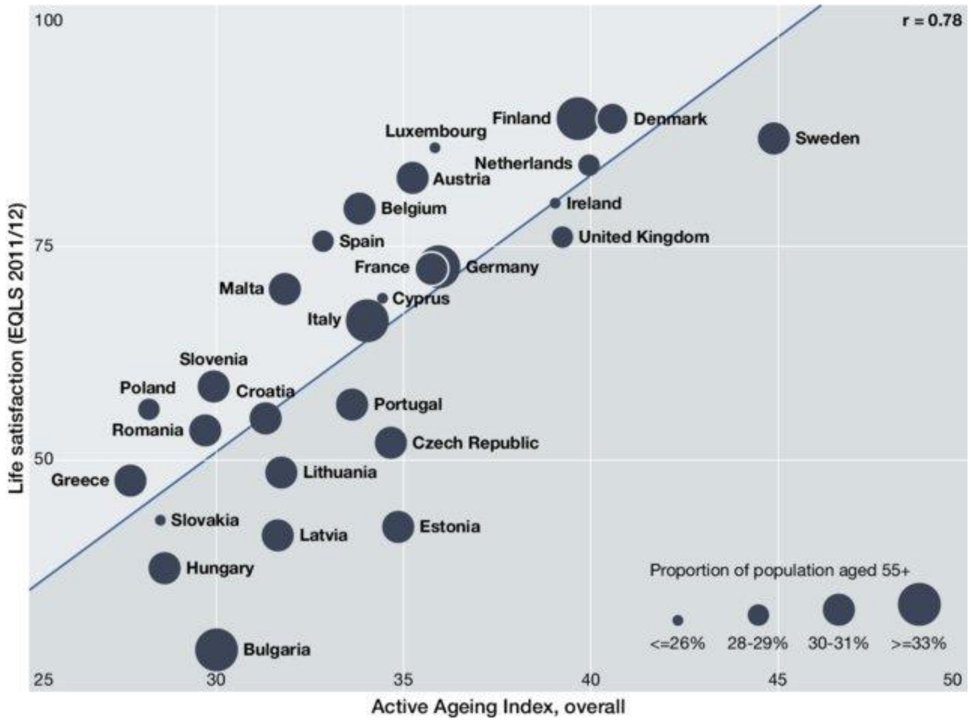


Figure 8: EU 28 Countries Life Satisfaction Levels. (Source: AAI report 2015)

ACTIVAGE Large Scale IoT Pilot (LSP) for Ageing Well has been conceived as a unique opportunity to scale up Use Cases (UCs) that the demand sides consider strategic to improve ageing well of the target populations. The aim of is to align, set-up, deploy and measure relevant Use Cases that provide a value for the users of the nine Deployment Sites across Spain, France, Italy, Germany, Greece, Finland and United Kingdom. 9 Use Cases that ACTIVAGE covers are shown in Figure 9. In most cases they address more than one category of needs and contribute to solve more than one AAI challenges.

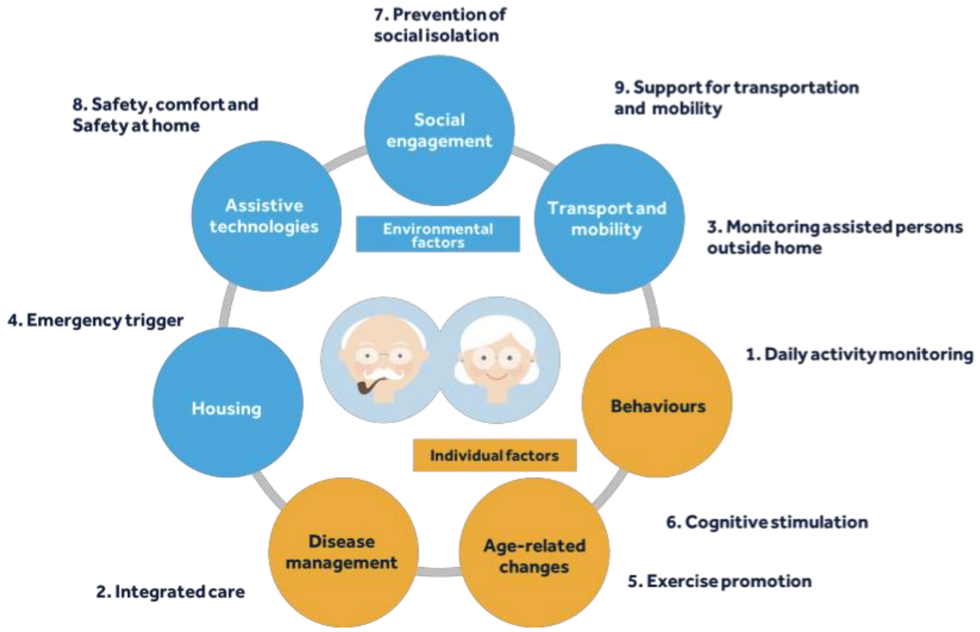


Figure 9. Mapping of needs for ageing well and ACTIVAGE use cases.

4.1.3 Smart cities

It is stated that citizens are moving to urban areas, currently 54% of population is living in cities and this will be increased to 66% by 2050 (according to United Nations[20]). Adding the fact that new technologies are disrupting and spreading across the market, it will obligate cities to "think smarter", providing better and more sustainable services and business models.

According to the latest IDC Worldwide Semi-annual Smart Cities Spending Guide [21], the investments in smart city related projects are increasing upon reaching 31€B in 2022. This investment is split as shown in Figure 10 with hardware and services as the main objective for the investments.

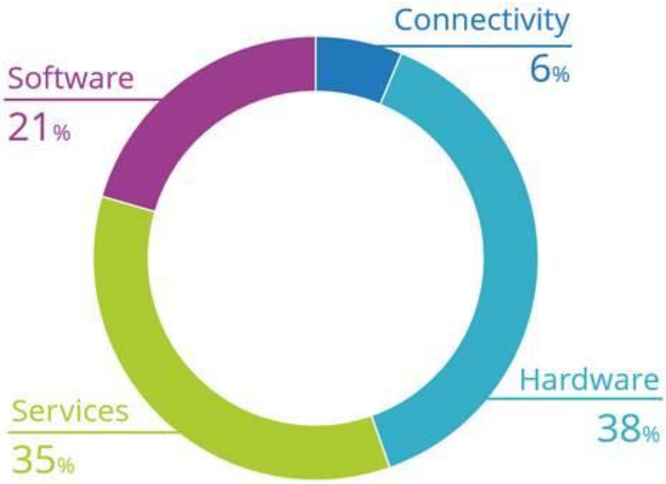


Figure 10 European Smart Cities Spending by Technology, 2018 (Source: IDC [52])

The Synchronicity LSP project oversees providing a global IoT Market where cities and business developers share digital services. The OASC principles, followed by the project, will guarantee the replicability of these services, one of the key factors about smart cities and IoT technologies. But it is needed to consider the huge market about devices, platforms, standards and protocol; which implies a barrier to cities in order to develop new services. Enabling this replicability will help to facilitate the usage of resources (lowering costs and development times) between different cities.

Synchronicity use cases are implemented by different pilots/cities (in the project called Reference Zones). These uses cases are about:

- Human-centric traffic management that focuses on stimulate bicycle usage by to optimize cycling experience (flows, waiting times, safety) and improve infrastructure planning leveraging data from different sources throughout the city.
- Multi-modal transportation: Seamlessly mix public and private transportation modes with new (shared) mobility services to enable smoother, more reliable and pleasant choice of transportation modes while improving city quality of life
- Community policy suite: Incorporate data-driven Agile Governance in city management and policy making that cuts across vertical organization models and enhances local authority responsiveness and improve citizen engagement

Technologies enable a more interactive world where users are not merely consumers, but also share and create new data. The circular flow of data between users, infrastructures, services, technologies, and vice versa, opens the possibility of new kind of disruptive services (something that already started in the era of Web 2.0). This is known by users, that are more open to participate in these kinds of ecosystems; aware that something is "obtained back". Empowered citizens (Empowering Cities, by EIU[21]) is the result of using these technologies to engage them to participate, collaborate in a more connected way:

- *Urban decision-making is going to rest on a much more active citizenry expressing preferences in real time through handheld devices*. - Maxwell Anderson, executive director, New Cities Foundation

  Manchester, Porto and Carouge, reference zones in Synchronicity, are working on providing new tools to City councils. The combination of real time, historical data and citizens collaboration, through data sharing, will support the definition, implementation and evaluation of new policies.

- But participation of these empowered users could come from many ways. For example, the Danish Technical & Environment Department launched an initiative to ask citizens to provide feedback about cycling paths in the city of Copenhagen through and iterative map. This active collaboration would be complemented with more passive actions, just automatically sharing real time bikes information while cycling. Several benefits are derived from these initiatives, improve life quality, reduce traffic congestion and pollutions, etc.

  Human-centric management use case in Synchronicity encourages to use bikes as mean of transport. Not only about improving routes but also prioritising the traffic of bikes and improving its infrastructure. Different IoT systems are involved together with the data shared by bikers.

In general, what citizens expect from a smarter city, and the new provided services, is better security and quality of life, and improvements in transportation and traffic management.

But it is no only about citizens, private sector could be also a helpful actor about participating in urban decisions. According to the article (Empowering cities[21]), 52% of companies would be more participative. For example, reporting infrastructure deficiencies, if there would be access to data and communication channels.

The same article remarks that 73% of executives are enthusiastic about help to engage citizens in order to understand the technology and available options and to make them more active about a collaborative city.

Thus, data sharing opens opportunities for new services development and opportunities, which is the main expected benefit from the private sector. Other important benefits are more related to getting insights from citizens to improve, and again, enable new services.

The other two stakeholders, municipalities and public agencies, and their expected benefits could be summarized as following (according to IDC research):

- Faster and better services for citizens, increasing trust and satisfaction level
- Leveraging competitive advantage to attract external funding and partners
- Operation optimization and costs reduction
- Insights on citizens challenges and needs
- Fostered economic growth and sustainability
- Data-driven policy making

But what are the main barriers and issues that municipalities are facing? Main barriers are related to technology. The heterogeneity of hardware to be deployed will cascade a set of different issues to be studied and solved (most of the times) case by case.

There is no one solution to fit all, and heterogeneity also implies different connectivity protocols and infrastructures. That will affect, of course, to the price in deployments. With the infrastructure up and running, you must gather and analyse the information, and again, many different platforms will be over the table asking for a decision choice.

Platforms, standards, protocols and hardware are some of the challenges to be faced. But there are others about the viability of business cases and value proposition. Without this viability study, use cases will not achieve a significant scale, taking the risk of finishing forgotten and with the feeling

of wasted time and resources. All these topics affecting to the implementation of smart cities have been studied and analysed by the AIOTI [22] in depth. In the same article some points are remarked as must for 2018:

- *Commercially viable cross-application use cases will be essential to the sustainable development of IoT-enabled smart cities…. use cases will continue to gain in commercial viability if they are built on common, interoperable platforms.*

  This is one of the main topics for Synchronicity, based on common OASC principles and data sharing, new implemented services would be not only cross-application but also replicable through different cities.

- *The industry must provide a solution for IoT platforms to exchange data… The major challenge will be found in privacy protection and compliance with the European Union's General Data Protection Regulation (GDPR)*

  Implementing scenarios and related technology is not an easy aspect to solve, but not because of the absence of existing solutions (IoT scenarios are complex 'per se'). Technology is already available and should be mature enough. But new topics needs to be considered: like how we use the technology in a secure and ethical way, respecting privacy aspects of data and not abusing of a so valuable resource.

- *IoT platforms must scale for stream processing, including video*

As conclusion, data sharing, and data standards are a key factor in order to enable the new services implementing smarter cities.

The engagement of citizens is directly related to services provided by private and public sector. Citizens will share more data if services are worthy, and companies need data, investment and infrastructure access from municipalities.

At the bottom, and fostering the creation of smart cities, municipalities looking for increasing trust and satisfaction level, and engaging citizens to participate in a more collaborative a connected city. Thus, everything is about data, and how this data flows in a circle around municipalities, citizens and companies. In the case of SYNCHRONICITY, the OASC principles rule these objectives, with special focus on NGSI as the data/interfaces standard.

4.1.4 Consumer IoT

Consumer IoT covers a large spectrum of applications and solutions ranging from connected home solutions to sport and fitness wearables to B2B2C markets such as the large-scale event market targeted by the MONICA project. In this section, we present a general overview of the consumer IoT market and a more specific analysis of the event and infrastructure market.

The following table present the different type of products and solution that falls in the spectrum of consumer IoT. The secondary use of consumer IoT data is often limited either by lack of direct interest or by ethical concerns over the use of personal data.

The overall market for consumer IoT, including connected home, sports and wellness markets is estimated by IDATE to reach 1.57 billion connected objects by 2025, with a 12.5% CAGR over the 2018-2025 timeframe.

The smart home market has the highest growth rate over the period (at 14.5% CAGR). Thanks to products that represent a break with the existing (connected speakers with virtual assistant, etc.) or with services with an added value perceived as strong such as connected alarm solutions.

For other applications, given the long life of home appliances and their price (especially large electrical appliances), the potential for many smart home products seems to be linked to the "classic" pace of device renewal as long as the price for a connected equipment is equivalent to the non-connected equivalent.

The sports and wellness market have been up to now the most dynamic and largest segment of the consumer IoT market, mainly driven by smart watches and connected armband. The connected wellness market is driven by consumers' desire to adopt a healthier lifestyle and/or improve their performance, in line with the recent trend towards "quantified self", the idea of quantifying and tracking their personal body data over time.

Table 2: Type of products and solution that falls in the spectrum of consumer IoT

Vertical	Usage	Connected Objects	Basic services provided	Advanced services (using data gathered by connected objects)
Home	Home improvement / Gardening	Lawnmower Laser Telemeter Humidity detector Infrared thermometer	Remote control Cloud based data storage Data monitoring over time	Predictive maintenance
	Energy	Thermostat Heaters Shutters HVAC Lights	Remote control	Optimization of energy consumption
	Security	Alarms Cameras Smoke detector	Remote control	Direct liaison with public safety
	White goods	Fridge Oven Dish washer Washing machine Furniture	Remote control	Personalized services (programmes, recipe, suggestions, etc.)
	Hi-fi	Connected Speakers	Remote control Music streaming	Personal assistant
Wellness and sports	Wellness	Hairbrush Toothbrush Scale	Monitoring of personal data	Usually none
	Sports	Band Watch Sport accessories	Monitoring of performance and personal data	Coaching
	Large scale events	Band Cash-less payment solutions Speakers and screen	Access control, payment, 2nd screen	Event follow-up and suggestions
Pets	Geo-localisation	Connected collar	Geo-localisation	None
	Health / Wellness	Activity tracker	Monitoring of performance	None
Toys	Awakening toys	Cuddly toy	Surveillance	None
	Toys	Educational games Remote control toys Imitation toys Interactives board games	Limited applications / Games	None

Connected sport, in particular wristbands and watches, is a high-profile vertical market, which benefits from value-added services (community aspect) and a willingness on the part of consumers to measure and share their performance. This market also comprises a large array of specific niche markets addressing different sports (connected tennis racket, surfboard, balls, etc.). However, the

overall usage rate of sports and wellness connected object still falls dramatically after a few months as the value added of many solutions remains low.

The overall demand for consumer IoT remains relatively low, as most applications remains concentrated on a niche market with both prices and lack of perceived added value limiting the direct adoption of consumer connected objects. The following graph present the result of a survey regarding purchase intentions of consumer connected objects.

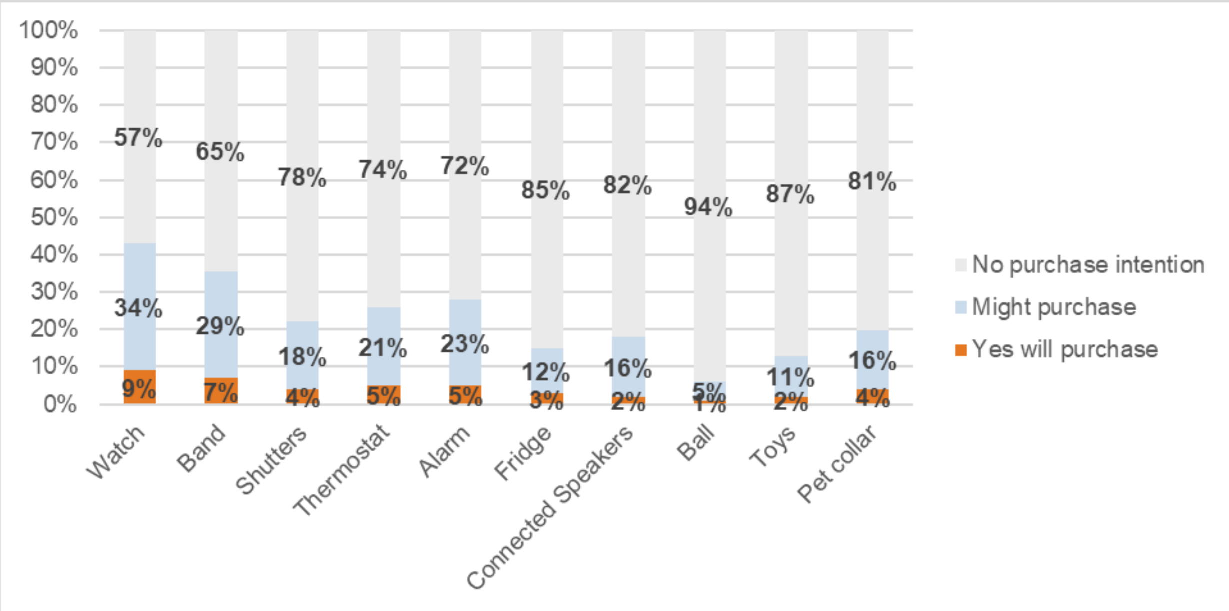


Figure 11: Purchase intention of consumer IoT objects (Source: IDATE [53])

The market of event related connected objects can be seen as a specific sub-segment of the sports and wellness wearables market. However, it is in most case a B2B2C market where the connected object is distributed to the end user by the event organiser. Two main type of events are concerned for now: sports events with the "connected stadium" market and music festival events.

The "connected stadium" business model main target is to increase the "game night" budget: purchase at the event by the public. This budget can reach 85 USD by customer for large US based events (such as the super bowl) and is usually much lower in Europe. Applications and connected objects targeting this market include solutions to deliver food and beverage in the stadium, but also 2nd screens settings providing alternate viewing angles to the public.

Regarding the music festival market, two digital solutions have been strongly developing in the last few years: cashless payment solutions (with again a willingness to increase participants consumption and to better control distribution) and access control solutions (with a target of reducing queues and waiting times). These solutions are increasingly merged in a single wearable band that is purchased by the end user for a relatively low price (usually around 1€) and as part of the ticket/registration fee.

4.1.5 Agriculture

Agricultural IoT embraces a wide family of devices, applications and solutions that support agricultural processes and operations. IoT technology is the key element behind what is commonly referred to as *smart farming*, as it allows data gathering, data processing, data analysis and asset automation, as well as decision support through data analytics.

There is general consensus on the fact that agriculture digitisation is a global trend in many regions of the world given the many benefits brought by digital innovations in this field. Investment in digital agriculture technologies are increasing year by year.

There is an increasing aggregated market push from a range of actors: from large corporations already established in the agricultural machinery market that are increasingly integrating IoT in their products and services, to mid-sized or small companies offering specific solutions addressing particular pain points of a farming modality.

Investments are also driven by public incentives. One prominent example is the IoF2020 project [11], backed by the European Commission with 30 million euros. IoF2020 gathers over 70 actors from the EU to build a major piloting effort aimed at validating the European IoT offer for the smart farming vertical, not only from a technological and operational point of view, but also from the business modelling, and market readiness and acceptability perspectives.

In terms of coverage within the agriculture vertical, there is virtually no application case lacking supply from the IoT market. A non-exhaustive list of use cases covered by IoT follows:

- Monitoring of environmental conditions through sensors: temperature, humidity, illumination, mineral composition, etc.
- Water/irrigation management through sensors and actuators
- Optimization of treatments for disease or pest control
- Optimization of fertilization
- Feed optimization and precision feeding
- Individual activity tracking of animals though wearable sensors: health monitoring, feeding patterns, oestrus detection, animal welfare monitoring
- Outdoors position tracking for grazing herds
- Waste management and waste optimization in farms
- Stock traceability in farms combining sensors and information systems: produce, feed and other intakes

Despite the global rise in digital agriculture technologies, the intensity of such investments varies greatly from territory to territory, and also on the farm typology within each territory.

We take the case of the EU as an example. A JRC survey published in 2014 showed that up to a 44% of farmers was not intending to do any investment in the period 2014-2020 [62]. However, a 40% of the surveyed farmers did intend to make investments in machinery and equipment over the next seven years, see Figure 12.

The main drivers for such investments were the improvement of working conditions in the farm, replacement of old equipment and reduction of operational costs.

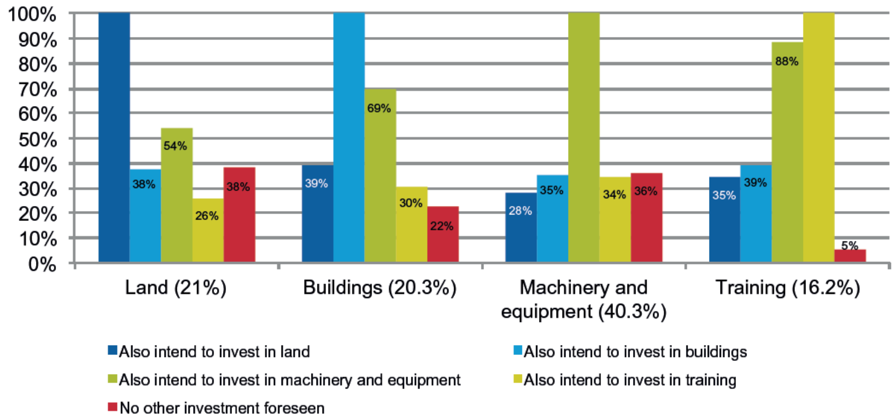
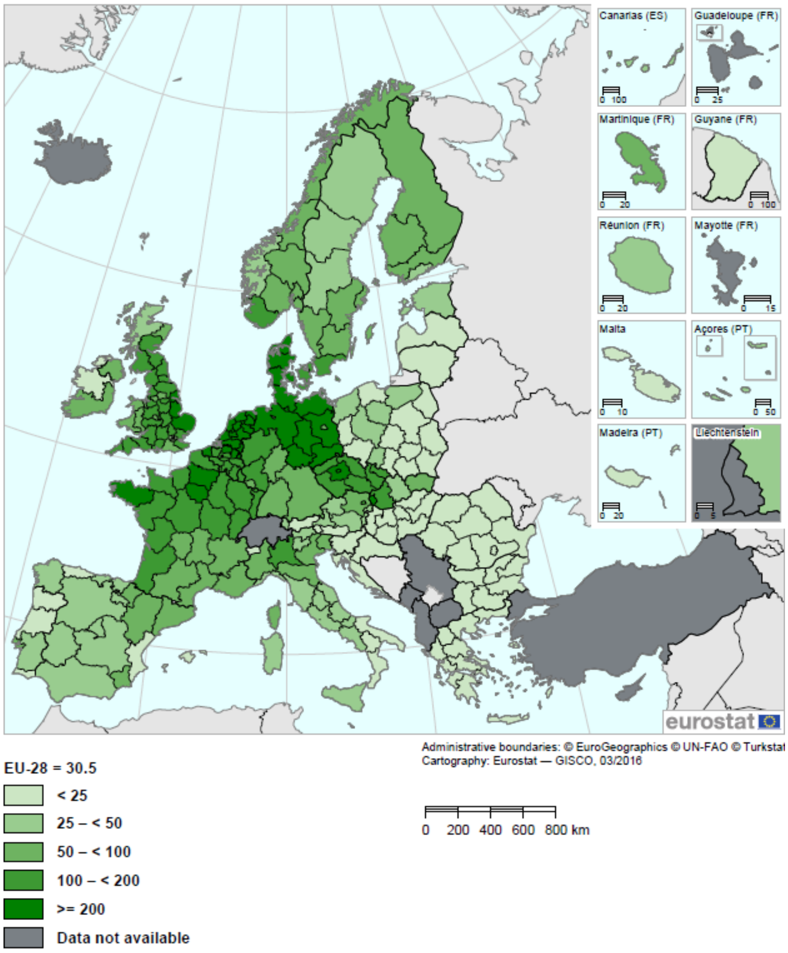


Figure 12: Distribution of intended investments per type of asset (Source: JRC [62])

A deeper analysis shows that more farmers would like to invest, but their financial positions do not leave room for such investments. A 2013 survey by Eurostat evidenced the atomisation of EU farm holdings, with 69% of farms considered *very small* or *small* (measured in economic output, i.e., monetary value of agricultural output at farm-gate prices) [61]. This can be seen in Figure 13, that displays the average size of EU farms.

Map 1: Average economic size of farm holdings, by NUTS 2 regions, 2013
(thousand EUR)



Note: all German regions, NUTS 1; Slovenia, national data; London (UKI), NUTS 1.
Source: Eurostat (online data code: ef_kvecsleg)

Figure 13: Average economic size of farm holdings in the EU in 2013 (Source: Eurostat [61])

Only farm holders with profitable businesses can allow the necessary investments, and this makes them the primary *early-adopter* category within the digital farming trend. A number of agricultural cooperatives in the EU are also showing as early-adopters, benefitting from their aggregated internal demand.

4.1.6 Manufacturing

Digital transformation is profoundly transforming Manufacturing industry, opening new business opportunities and new production models for companies to enhance and expand their value chain. Central to this manufacturing transformation, are IoT solutions that allow the creation of the connected Factory of the Future, an ecosystem where everything is connected and optimized from supply chain to R&D to customer service.

The journey towards the Factory of the Future has a strategic relevance also for the European economy and the societal development and growth. The socio-economic and financial numbers, as well as the predictions towards 2020, highlight the need for further IT support in this sector. This is for example well presented in the EFFRA policy report for the Factories of the Future [19], which develops around the key research and innovation priorities as the roadmap for the manufacturing 2030 vision. As stated there, ICT aspires innovation in the manufacturing intelligence through enabling the management of huge volumes of data being collected from collaborative supply networks and connected devices and optimising the production planning and scheduling.

IDC European Vertical Markets Survey 2017 confirms that Manufacturing is among top adopters of IoT, with 28% of European organizations (average is 23%) already using the technology and 7% planning to adopt it in 2018. This driven by manufacturing subindustries such as Automotive, Aerospace and defence, and Wearing apparel, that lead IoT adoption among European Manufacturing companies.

One of the key challenges European manufacturers are now struggling with is bringing IoT initiatives beyond low added value usage. Looking at the way in which IoT is currently used within organizations in the sector, IDC research highlights that for most of Manufacturing IoT adopters (54%) IoT data are merely collected and in certain cases analysed, but without any impact on business and processes yet. Only 29% of European Manufacturing IoT adopters are applying insights from IoT data for automation and operative business enhancement. On the bright side, there are also examples of manufacturers using IoT for going beyond basic IoT usages, with 17% (the lowest percentage among industries part of IDC European Vertical Markets Survey 2017 sample) of European adopters applying IoT for testing new business models and fostering additional revenues.

Key driver of IoT adoption and spending among European manufacturers is the need to improve automation and factory's operations, combining real time data coming from multiple sources with predictive analytics. Organizations can potentially leverage IoT combined with artificial intelligence to improve decision making, optimize production, enhance customer service levels, and reduce costs — for example, through predictive maintenance, lessening the impact of unplanned downtime, lowering energy costs and eliminating unnecessary maintenance. IoT, especially in the manufacturing sector, is also leading to an even closer convergence between the IT and OT (operational technology) worlds. Operational equipment has become widely instrumented, and increasingly interconnected, with IoT being a major contributor to connectivity. To leverage that connectivity, manufacturers are finding that the approach requires collaboration between information technology and operational technology and their respective organizations.

OT includes the hardware and software that monitors and manages operational assets and processes on the plant floor and in the supply chain, for example, supervisory control and data acquisition (SCADA), meters, valves, sensors, and data historians. The fundamental ability to understand the business process, as well as work with the data that process generates, is leading to changes in how IT and OT work together on projects. The convergence of these two paradigms is fostered by IoT solutions, leading to new ecosystem and partnerships scenarios and to a better alignment between IT departments and Line of business units.

When comparing Manufacturing with other industries, this has been certainly one of trailblazer sector in the past, glimpsing IoT opportunities many years ago. It has been a long run since initial IoT focus on production assets and phases to nowadays, where IoT applications also expand to design/engineering and post-sales phases.

Among IoT use cases, current Manufacturing IoT adoption is driven by Predictive Maintenance, Remote assistance on products, and sensor-based control and coordination of shop floor devices [54]. Supply-chain track & trace applications show high expectations for the next years, in terms of European adoption plans.

According to the latest IDC Worldwide Semi-annual Internet of Things Spending Guide, forecasting IoT spending across more than 50 countries around the globe, Europe represents more than 15% of the Manufacturing global IoT spending in 2018, with Discrete manufacturing being the second largest industry for European IoT spending. Germany, Italy, and France lead Manufacturing European IoT Investments, representing more than 50% of the regional spending in the sector. Top manufacturing use cases in terms of spending for 2018 are:

- **Production asset management**, where IoT helps companies remotely track, monitor, and maintain industrial manufacturing devices that are part of the production value chain. This

entails regularly assessing the equipment conditions and being able to remotely diagnose an equipment failure before it happens by analysing the live stream of data produced by the machine (predictive maintenance).

- **Autonomous Operations**, where IoT enables the different components in the manufacturing field – e.g. machine tools, robots, conveyor belts etc.– to autonomously exchange information, trigger actions and control each other independently. This also allowing a real-time assessment of current demand and capacity availability continuously and intelligently resequencing work on the factory shop floor.

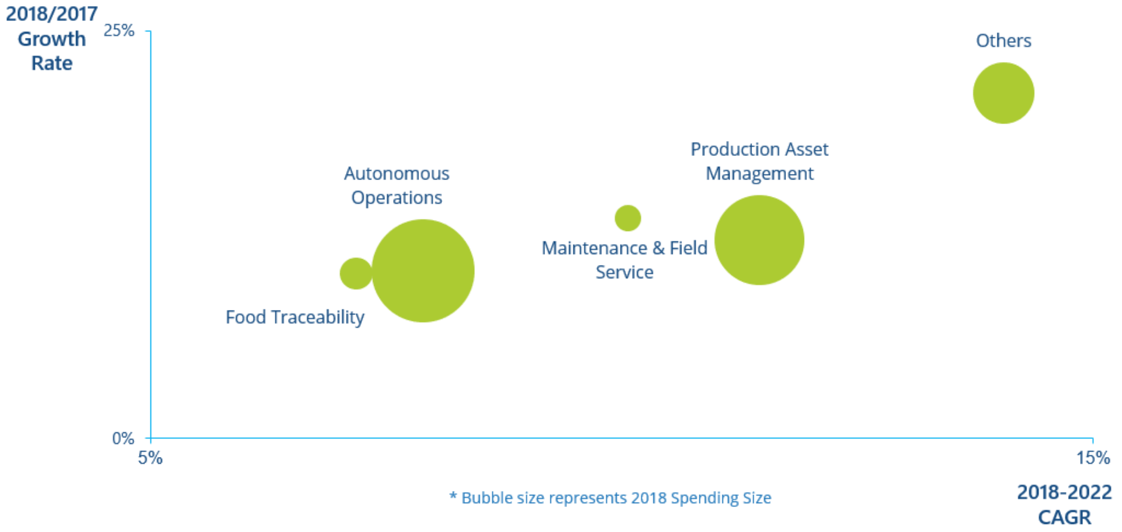


Figure 5: European Top Manufacturing IoT Use Cases by Spending (Source: IDC [48])

4.1.7 Energy

Energy utilities in water, electricity or gas vectors used to base, over the past decades, their core business on one-way distribution of services, something abruptly changing nowadays [2].

This change is not just a consequence of the recent de-regulation and/or the former public bodies becoming private (something which indeed disrupted the scenario), but also as a result of new available technologies, fostering the inclusion of new energy resources, enhanced generation capabilities and emerging storage options. This led to a new scenario of highly dynamic ecosystems of producers, distributors retailers and prosumers.

IoT can be certainly considered as a core enabler to this energy revolution, as the granularity, speed and accuracy of the data that can be obtained now by energy Utilities is exponentially increasing.

The demand side is also under a significative revolution yet to be fully adopted when electric cars are fully adopted. The combination of these kind of vehicles with the rise of renewables and the smart transformation of the grid results on a need to provide higher and higher degrees of flexibility to the system.

But IoT and digital technologies are not just impacting the Utility/Network operator side. Customer behaviours are also deeply affected and transformed.

Consumers are turning into prosumers, and their detailed information regarding available generation/storage and instantaneous demand is very valuable to run optimization processes and balancing mechanisms on the network. This situation of real time tracking, and optimization would be unrealisable without the help of IoT technologies.

These changes on the demand side are paving the way for the implantation of novel services for Utilities to offer, including not just traditional energy services (or evolution of conventional services using the new available information) but also a whole new bunch of additional added-value propositions for tangent sectors such as Factory 4.0, smart cities and mobility.

Furthermore, utilities are no longer the only big player on the energy field, as new players from other strategic sectors as telecommunications, Information Technology or manufacturing are entering the game offering smart services oriented to diverse targets in the current hot research topics of smart homes, building energy management and electric vehicles.

The rules of the game are changing fast. Energy utilities are facing a great challenge, and they will have to decide in the very near future what is their strategic way forward. They can opt for a conservative approach on staying as a pure commodity just embracing the new technologies and adapting their services to the new demand or becoming a much richer added value service provider for multiple kind of energy needs and fully embrace the new digital era fostered by the adoption of IoT. The success on both approaches would certainly rely on a deep transformation over the whole value chain to adapt to the new demand and supply needs, including customer relations, operations, business models and compliance. An efficient implementation of these strategies will translate into solid growth perspectives.

Finally, as shown in Figure 14, growth perspectives for the energy sector are very promising. Most of them rely on the adoption of digital technologies and specially IoT technologies. From those on the figure, it is interesting to point out three major ones spinning around the Internet of Things adoption:

- 27% of EU energy should come from renewables by 2030
- $138bn should be spent in smart homes in 2023
- 85% of utilities will speed up digital innovations by 2019

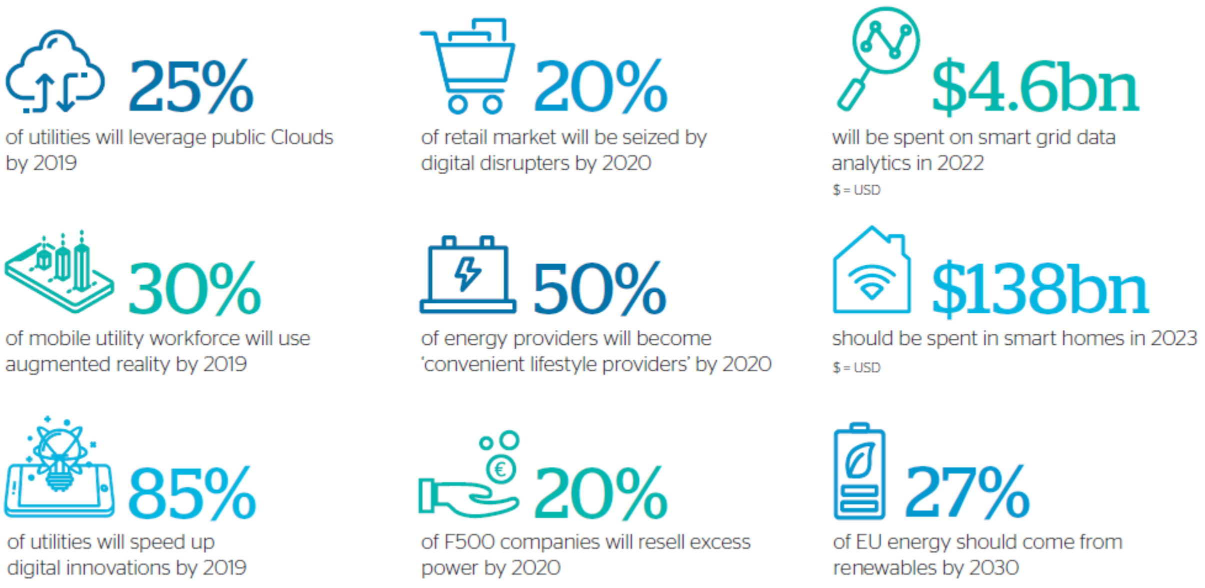


Figure 14: Energy landscape market analysis and trends (Source: Gartner [3]).

In the recent past, the energy market was ruled by technology push. The current change basically on the demand side, is urging for a change, therefore driven by a market pull perspective.

Policy and decision makers must now work on ways to engage customers, on the one hand, and incentivize energy network operators and utilities, on the other hand, to invest and adopt digital technologies, including IoT, and move from the static traditional approach [4].

As more and more novel smart grid technologies are being implemented, there is a need for a clearer market design, including the regulation of roles and responsibilities along the whole value

chain. This new scenario is expected to foster interoperability and have a positive impact on final customers and citizens. It is also true that uncertainty might also influence on a negative manner as for potential investors and new market players.

The change on the perspective and adoption of the market pull approach is driven by two main factors, mainly the role changes in consumers and the adoption of standards.

Energy consumers are currently (and will be increasingly more in the future) no longer just unidirectional users of utility services, but they are now active players looking for optimization services able to better manage their smart homes, efficient buildings and generation/storage capabilities. In addition, their demand curves are significantly changing due to the adoption of IoT technologies inside smart appliances and also as a result of the penetration of electric cars [2].

The prosumer figure is currently well stablished, due to the rising production capacity in the form of solar generation and wind power equipment. Moreover, consumers are also surrounding the energy equipment with intelligent IoT connected devices which are fostering new ways to relation with conventional energy providers. This is the seed of a whole new scenario in which competition with new market is rising, especially interesting for IoT start-ups dealing with consumption optimization and appliance makers smartening their devices.

Energy utilities shall them offer new competitive services able to make use of the relevant new information available and also relevant and valuable for a new kind of users who are better informed, and technology empowered. The power of IoT data poses as a cornerstone in this respect, allowing to present best offers and a mix of value-added services.

Common use and adoption of relevant standards are also key, as introduced earlier, to foster the new market pull perspective. Among all standards, for the market analysis on new demand side patterns, Demand Response is especially relevant, as it is critical for grid stabilization. When talking about Demand Respond, OpenADR [5]is the most widely adopted reference.

Demand response are those demand-side changes on normal consumption made as a result on price changes or incentive payments for low electricity usage on certain periods where the system is overloaded.

Automated Demand Response is the way energy operators can optimize and reduce the implementation cost of Demand Response policies while increasing the reliability and reducing the effort needed to fully implement it. Automation on Demand Response is also the key enabler to real-time operation with customer interaction and reaction on retail rates.

This automation relies on deep knowledge of instantaneous demand (fostered by the implantation of IoT devices) and reliable communication links to enable efficient interaction between all relevant players such as producers, aggregators and customers. Not having a standard in place for Demand Respond will translate into high integration and operation costs.

OpenADR is and standardized and open manner to communicate Demand Respond signal between relevant actors, using a common language and relying on already existing and IP-based communication layer. OpenADR is currently widely endorse in the energy industry. The standard is backed up with an alliance of industry stakeholders, also in charge of fostering its development, implementation and promotion. This standard also relies on already existing standards such as OASIS, UCA and NAESB.

All aforementioned new opportunities faced by the energy sector and specially those regarding the adoption of electric vehicles, smart homes, smart cities, etc. will impact on a significant change of pace and accelerate the sector transformation [2].

Multiple new players are entering the market and introducing their innovations. Those new market entrants range from very technological start-ups to very large companies (including Tesla or Google).

As IoT is being fully adopted in the energy sector, new challenges and opportunities arise for market players. These elements, as presented below should certainly take into consideration for the strategic way forward.

- Adopt a prosumer centric approach, delivering fully customized and personalized services for end users and also, in the future, smart things enabled by IoT.
- Make use of all the relevant data gathered by IoT devices and develop a data orchestration able to, on the one hand, monetize the information and, on the other hand, be flexible enough to adapt to market changes and consumer behaviours in a real-time dynamic and prescriptive way.
- Understand the IoT ecosystem and make use of open platform foundations and automation processes, enabling the creation of most appropriate services quickly, cost-effectively and efficiently tailored to the customer needs.

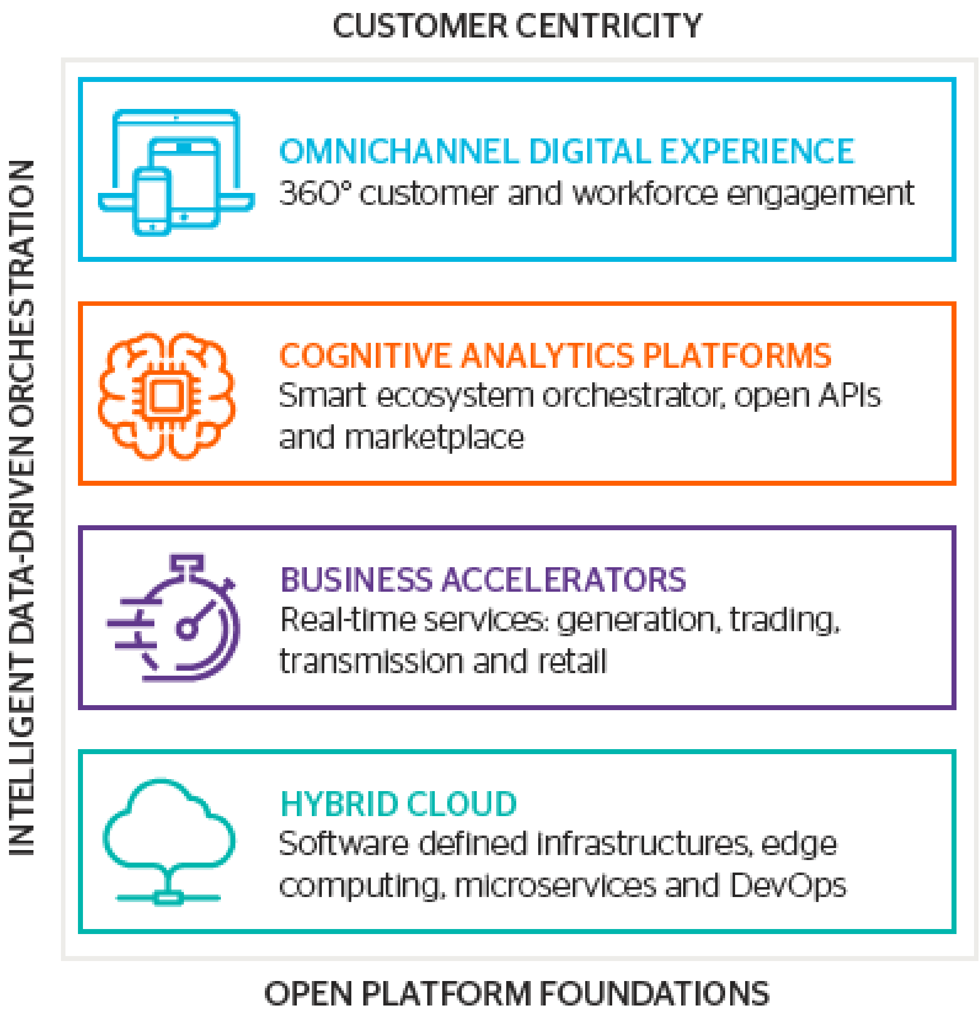


Figure 15: Next-generation architecture for future ready energy utilities, (Source: Goldman-Sachs [2]).

Surviving (and succeeding) in the new scenario requires stakeholders to reassess their position and strategy as per the energy value chain. IoT technology is enabling a wide plethora of new services, ranging from smart energy management, vehicle-to-grid and grid-to-vehicle services, monetizing data retrieved from customers, smart home/building management or even more ambitious management scenarios for smart cities and microgrids.

Different verticals are collapsing into the energy sector, being this benefitted from the capabilities of the joint scenario. Federation of stakeholders and building of operative and profitable ecosystems are paramount for energy sector players to succeed.

4.2 Balancing market pull and technology push

4.2.1 Market and technology

The concept of linking a series of objects in a network of smart devices has been around since the early 1980s. However, IoT as a phenomenon per se where things and objects can be seamlessly and permanently connected through the Internet, has truly developed at the end of the last decade and has not stopped to evolve ever since. Nowadays, technology vendors seem to have reached such an advanced point in their product development that IoT has now become a viable business proposition. At the same time, the process of digital transformation continues unabated and companies across all industries and sectors are starting to experience first-hand the competitive advantages of full IoT implementations in their daily operations.

While technology vendors continue to enlarge their IoT offerings leveraging ever innovative solutions in analytics software, cloud computing, hardware components and IT services (exerting therefore a powerful technology-push effect), the market is still affected by a series of potential hindrances that could relent the demand pull for IoT. These issues vary from industry to industry but are, by and large, related to unsolved security and privacy concerns and the uncertainty surrounding the actual availability, deployment potential and business exploitation of key technology developments that complement the IoT offering.

This is notably the case of 5G, for example, whose real capability to support IoT is still unclear, as well as the case of the future development of IoT platforms, which still tend to operate predominantly at horizontal level, while the market is now requesting IoT platforms that really understand vertical and industry-specific needs. The issues (of all sorts, including ethical and social) surrounding the evolution of Artificial Intelligence and the uncertainty around the potential of Blockchain for IoT contribute to affect the potential development of IoT demand.

Beyond this cautious note, however, the IoT market is now a solid reality, with more than 40% of European companies already using IoT solutions or currently developing IoT pilot projects [47]. The demand for Internet of Things hardware, software, services, and connectivity will grow from $580.4 billion in 2016 to $1.13 trillion in 2021 at a CAGR of 14.4% at worldwide level according to IDC [55]. Growth for EMEA will outpace the other regions' over the forecast period, growing at a rate of 17.2% and reaching $263.7 billion in 2021. The largest use cases seeing spending include manufacturing operations, freight monitoring, smart buildings, and production asset management. In Europe specifically, the IoT market is expected to reach €127 billion in 2018 and grow at a compound annual growth rate (CAGR) of 13% in the next four years [48]. In fact, IoT adopters will be called to finally move beyond initial proof of concepts (PoCs) toward broader and forward-looking implementations, and IoT players will be expected to consolidate their partnership strategies while developing stronger vertical specialization.

Automotive:

In the automotive sector, both the technology-push and the demand-pull effects are at play. Indeed, technology players have taken the lead in a rapidly evolving automotive market while the automotive industry is increasingly turning to new technologies to compete in an industry that is more and more characterized by increased digitalization and electrification. The automobile continues to be the largest single application growth opportunity for technology providers according to recent research from IDC [56]. While the worldwide automobile and light commercial vehicle market only grew by 4.2% in 2016, the automotive semiconductor market outpaced it, growing to $32.9 billion in 2016, up 11.0% year over year, according to IDC's Semiconductor Application Forecaster. Key trends such as connectivity and in-vehicle infotainment (IVI), electrification, and advanced driver assistance systems (ADAS) will continue to drive growth in the automotive semiconductor market to $49.9 billion in 2021, representing a five-year compound annual growth rate (CAGR) of 8.7%.

On the other hand, the demand for more mobility (cleaner, safer, more flexible and more intelligent) exercises a powerful force for the application and deployment of IoT solutions to the industry. This demand is stimulated by shifting mobility needs but also by a marked government action for safer and cleaner transportation. For example, regulations like backup cameras required in vehicles or adoption of advanced driver-assist systems by different governments will require some form of video system in automobiles and increase the deployment and application of IoT solutions in the industry.

Health:

According to IDC's European Vertical Markets Survey 2016, IoT is the fastest growing Innovation Accelerator in healthcare, growing faster than cognitive/artificial intelligence (AI), next-generation security, 3D printing, augmented reality, and robotics. Indeed, IoT is one of the most promising concepts in eHealth. It can help improve efficiency, reduce cost, increase the quality of healthcare provider operations, and connect providers with the patient ecosystem, thereby driving the implementation of integrated-care initiatives. IoT technologies can contribute to hospitals' efforts in reducing the number of beds, improve their perceived patient care quality, and improve overall quality of care delivered — all of which are key concerns of the healthcare sector today.

While these premises advocate for further positive developments of IoT in the healthcare sector, the current demand-pull and technology-push dynamics appear rather moderate in this sector when compared to other segments like manufacturing or energy. In healthcare, IoT has mainly been centered so far on building management (such as temperature tracking) and RFID technologies to monitor and track assets (such as beds, medical equipment, patients, and clinicians). The potential is broad, and in recent years, there has been a steady growth of IoT initiatives from an innovation and pilot perspective as well as full-scale implementation. In fact, IDC's European Vertical Markets Survey (November 2016) data shows that the widespread implementation of Internet of Things technologies is a focus area for most hospitals and other healthcare providers. But the actual use of the technologies is only at a very preliminary stage, where data is collected but not yet used to enhance the automation and operation of business processes.

Hospitals are ahead of the curve in terms of leveraging IoT data for analysis compared with other healthcare providers; this is due to the wider range of IoT use cases that can be implemented in hospitals compared with primary and community care. They are also usually one entity with one budget, whereas other healthcare providers are more fragmented and are therefore not able to invest in expensive IoT infrastructure. As a result, demand-pull forces will remain rather weak in the healthcare sector, at least over the next few years. Technology-push dynamics will continue to exert their influence, but it is unlikely that one single IoT platform dominate the healthcare sector, providing an end-to-end solution in the near future. Market leaders will be those platforms able to collaborate and deliver co-created solutions bringing their core platform together with best-of-breed healthcare partner solutions to provide device, connectivity, and data for the widest possible range of market applications and able to adapt them to specific healthcare requirements.

Smart Cities:

A similar dynamic is at play in the smart city environment. On the one hand, citizens (the market-pull) expect new, enhanced services, increased security, better quality of life and improvements in transportation and traffic conditions from IoT solutions applied to urban contexts. Smart Cities focus on the goals of sustainable development of economic and environment, citizen engagement, technology innovation, and management evolution as well as builds an ecosystem of partners to fundamentally change and improve the quality of citizens' daily life.

On the other hand, new, disruptive technologies are rapidly gaining momentum allowing the ever-growing urban areas to become smarter and provide more sustainable and effective services to the increasing urban population. Smart Cities are indeed entities that will be economic zones, city districts, a county, or a city group all in once. Their intelligence is characterized by using ICT

technology to improve citizens' lives, provide a developed environment for industries with potentials, and offer more flexible government governance methods to obtain resources to create more efficient and sustainable ways for city development. In this respect, IoT solutions and their architecture design focused on data sharing greatly improve information sharing and collaboration between the different departments of a municipal government or, indeed, through multiple municipalities and actors and become indeed *the* fundamental enabler of new Smart Cities.

That said, though, in the case of smart cities the demand-driven dynamic seems to play a leading role in fostering the application and deployment of IoT solutions. The enormous variety of devices, platforms, standards and protocol that still characterizes the IoT deployment in smart cities represent a barrier for urban area willing to develop new, IoT-based services. Increasing the interoperability among the different platforms and devices, improving the standardization processes among standards and protocols and enabling the replicability of pilots and projects between different cities would certainly help meeting the increasing and more sophisticated demand for smart city services coming from citizens, the private sector, and the local municipalities leading to increased trust and satisfaction levels, a creation of a level-playing field for private players opening up new streams of funding and new partners, reducing and optimizing operation costs and, all in all, fostering urban areas' economic growth and sustainability.

Farming and smart agriculture:

The farming and smart agriculture market is seeing a combined push of technology and rise of the demand, but both are still for now limited to a small subset of the potential agriculture market.

Large farming equipment providers are increasingly integrating connectivity and IoT based solutions in their traditional range of products. This include a large diversity of products from connected watering systems, fields sensors and weather stations to connected tractors and implements or even drones.

However, this technology push is facing a market where equipment life is usually very long. The average age of tractors in Germany (a country with a comparatively modern agriculture) is 27.5 years. The main reason for this longevity is the high purchasing costs of equipment. Thus, although most agricultural equipment sold nowadays integrates digital capabilities, most of the fleet remains pre-digital tractors, implements and machines that will take a long time to replace.

Animal farming (specially in dairy and beef production) is seeing a relevant push, with an increasing offer of a range of IoT-enabled devices and machinery, from costly milking stations to lower cost activity monitoring wearables for animals. Again, large investment decisions tend to take place when the old equipment needs replacement.

A demand for smart farming is also starting to rise, but mostly concentrated on a small market of larger-scale exploitations or syndicated buyers. The ability of farmers to invest and to modernize their practices of production face important disparities across the EU and even within individual member states.

Although cooperatives are beginning to act as demand aggregators for innovative digital technologies, a large majority of EU agricultural holdings are small, and typically run by families. These face often a tight economic situation with very limited investment capacity in new production tools and limited access to credit. Additionally, the workforce is ageing, with over 56% over 55 in Europe (2013). The digital skills of the workforce are thus limited and require additional investment in training to adopt digital technologies.

Manufacturing:

In the manufacturing industry a balanced act of technology-push and demand-pull is at play when it comes to the implementation of IoT solutions. Market forces for IoT in manufacturing are driven by a straightforward motivation: Manufacturers make capital investments into technology, which will, in turn, create long-term reductions in operational expenses. Networked machines, sensors,

and so forth, do not make mistakes or require breaks, sick days, or training, and thus offer a reliable and cost-effective way to improve efficiency. Indeed, according to IDC research [57], the vast majority of European manufacturers is familiar with the concept of Internet of Things (IoT), with one-third having already deployed a solution in conjunction with other initiatives such as cloud and security. What is more, European manufacturers consider that IoT will have a strategic impact on their business (i.e., compete more effectively in the market). However, up-front costs, security, and privacy issues represent stumbling blocks in the way of fully transforming business models. The top factors driving the investment in an IoT solution are process automation and improving business productivity, both internally and across customer relationship. Popular deployment areas also include security systems, fleet tracking, and warehouse management. For this reason, rather than hardware, connectivity and data management/software are the most sought-after product features that influence manufacturers sourcing decisions.

While market forces demand more IoT implementations, the situation in the technology camp is more complicated. Manufacturers, in Europe and elsewhere, raise increasing concerns on IoT's impact on business security and potential lack of interoperability. What is more, as technology pushes for the application of IoT into a broader range of commercial opportunities, IoT solutions appear to be misinterpret the real end-user needs. In fact, IoT applications were born as enterprise B2B applications, which have now become B2B2C. For example, fleet vehicle operators now directly engage with IoT devices that can measure their physical condition as well as their driving behaviour. As B2C companies rush to exploit new IoT applications, pushing technology to potential end users no longer works. IoT companies with traditional B2B business models and B2B2C distribution channels have been pushing IoT technology rather than addressing the pull of customer needs and tastes. However, going forward, the pull of user experience will drive market demand, and product design will be critical to getting consumers to adopt offerings in this new IoT 2.0 world.

Energy:

The energy sector has profoundly affected by the current process of digital transformation which has influenced both the demand-pull forces as well as the technology-push mechanism. This process of digitalization in the energy industry has been not only accelerated by recent de-regulation moves and/or the former public bodies becoming private (something which indeed disrupted the scenario), but also as a result of new available technologies, fostering the inclusion of new energy resources, enhanced generation capabilities and emerging storage options. IoT can be certainly considered as a core enabler to this energy revolution, as the granularity, speed and accuracy of the data that can be obtained now by energy Utilities is exponentially increasing.

The demand for IoT solutions in the Energy sector is also experiencing an acceleration, with the introduction of electric cars and the rise of renewables pushing for a smart transformation of the grid to provide higher degrees of flexibility to the system. Recent IDC research forecast the total spending on IoT solutions in the infrastructure sector (i.e. telecommunications and utilities) to be at 32.6 billion US dollar in 2021 marking a significant Compound Annual Growth Rate (CAGR) of 11.6% over the period 2016-2021 [58]. Smart electricity metering solutions and the better utilization of mission-critical assets represent the main demand drivers behind these investments.

Smart electricity metering has been under the spotlight for the past several years. Italy and some Nordic countries have pioneered the technology, and operators there are preparing their second-generation rollouts. Installation volumes have more recently built up elsewhere in Europe, with rollouts accelerating and, in some cases, reaching the final stretch across major countries such Spain, the Netherlands, the U.K., and France. Germany recently passed a law mandating smart electricity metering for midsize to large users, with the bulk of the rollout starting in 2020. For commodities (excluding electricity), smart water metering will remain marginal across most of Europe for the foreseeable future, and gas smart meters are being installed across a number of large European markets such as France, the U.K., Italy, Austria, and Ireland. IoT in utilities will

also come from use cases supporting better utilization of mission-critical assets. On one hand is the utilities' move to smarter networks, where IoT plays a pivotal role in automating transmission, transport, and distribution networks, optimizing the flow of commodity, while ensuring an efficient and reliable service. Use cases in this category span substation and gas pressure reduction automation, distributed energy resources management, quality control, and leakage reduction. The evolving role of the electricity distribution system will also increasingly be a demand driver for IoT technology, including for aggregating and managing end-user demand or for managing increasingly self-sufficient portions of the grid, such as in demand response, virtual power plants, and microgrids. Finally, IoT is increasingly visible in the management of mobile resources, particularly in asset operations, with fleet and workforce management and sensor-based health and safety applications as examples.

Consumer IoT:

Consumer, driven by the smart home revolution and personal-wellness-related markets (including connected wearables), will be the fastest-growing IoT vertical in the next few years, exceeding $33 billion in European spending by 2020 according to IDC [58].

The smart home market is rapidly evolving beyond the consolidated security solution and toward a full automation concept driving both demand-pull forces as well as exerting a strong technology push. Demand-pull is significantly sustained by personal wellness and connected smart clothing solutions which represent one of the largest portions of IoT consumer spending. The market is still growing at rapid pace, and two trends characterize the sector. On one side, new players (e.g., traditional watch brands) are entering the market, a sign of increased competition in the market going far beyond a pure IT-player battle.

On the technology-push side, existing players are facing the challenge to bring smart clothing to a wider audience, enhancing standalone connectivity capabilities and going beyond niche use cases and applications (e.g., sports-specialized solutions). Home automation solutions are taking centre stage, both in terms of new implementation on new buildings and retrofitting on old infrastructures. The focus is now on elevating the intelligence level of this solution with advance video analytics applications, voice recognition capabilities, among others. Finding the perfect mix between IoT and cognitive features, full integration with other home solutions, and user-friendly experience will be key for players ready to emerge in the vibrant smart home ecosystem.

4.2.2 Privacy and security implications

IoT reshapes the collection of data from an ‘active’ feature of human-computer interaction to a ‘passive’ one where devices communicate and exchange data among themselves. Such developments have important privacy and security implications that organizations involved in IoT-related projects need to take into consideration. From the point of view of the enhancement of security, organisations must prioritize the protection of privacy, data, people and system if they want to respond to the market needs. Create-IoT has already highlighted in previous contributions the role and impact of the General European Data Protection Regulation (GDPR) which is fully enforceable from May 25th, 2018 is to this extent a point of reference [36][37]. The GDPR empowers data subjects for their protection of personal data by granting them a set of rights and also provides for specific procedures as far as the export of personal data outside of the EU is concerned. Organizations have to take seriously the implementation of the GDPR as they can be fined up to 20 million euros or 4% of their global annual revenue, whichever is greater, for violating this regulation. For instance, a key issue to deal with in the context of IoT devices is and will be the proper documentation of consent of the end-users, organizations need to be able to demonstrate that they have obtained an explicit consent for all data collected from an individual as well as reason and purpose of using and processing personal data. The consent given by the user can also be withdrawn. Concerns and actions in this field are also taking place in other parts of the world, for instance in the United States where it has been highlighted how a) enabling unauthorized

access and misuse of personal information, b) facilitating attacks on other systems and c) creating risk for personal safety are all concerns that need to be addressed [38].

IoT is now entering a critical phase, the new 5G technology will play a key role and will be instrumental in driving the ongoing digital transformation, responding to a wide variety of communication needs. In the context of an increasingly ubiquitous digital environment there will be the need to integrate security and privacy early in the innovation process acting by design rather than by mere afterthought. This will require, besides the enforcement of applicable legal norms, a specific work on human-centric innovation and standardization which take into account technological and societal considerations. From a market perspective security and privacy should therefore not be seen as obstacles to market development or burdens in the system design, but rather as a tool to foster trust from the end-users [39]. With an increase in spending and a surge in the demand of IoT devices consumers will value products which will reduce the risks both for organizations and customers [40]. If, on the contrary, there will be a race to the bottom introducing low quality-low price devices into the market organizations will run the risk of compromising the protection of personal data of users and their reputation.

5. ALIGNMENT OF IOT ACTIVITIES AT THE NATIONAL LEVEL

5.1 IoT national strategies priorities

In this section we present an analysis of the apparent priorities IoT national strategies and the potential synergies with the LSP programme. This analysis complements the broad survey of European IoT national strategies presented in deliverable 1.2 and is also based on the analysis of the national IoT initiatives across industrial sectors presented in section 5.3 of this deliverable.

5.1.1 A large array of instruments

National strategies can take different forms depending on the policy-makers objectives and on local ideology regarding the role of state policy intervention in the industrial domain. They can range from:

- **Prescriptive regulations**, for example imposing the deployment of a technology to existing or new products on the market (such as the eCall regulation in Europe). These are usually very efficient to develop a market but usually apply only to few domains (security related regulations…)
- **Public procurement,** when a nation-state, region or cities purchase technology directly for its own use. This can apply to some smart-city and energy deployments and if applied with consistency on a large enough scale can result in large scale impacts for an industry.
- **Direct or indirect investment in industry,** this can take the form of direct investment by the state or incentive tax cuts to support the development of an industrial domain. This form of support can be effective in developing a specific domain.
- **Research funding,** through the direct set up of research centre, the funding of projects or here again through incentive tax policies pushing industrials to invest in specific R&D topics. This type of funding is often more forward looking, betting on the technologies of tomorrow rather than pushing for the adoption of existing solutions.
- **General incitation,** through non-prescriptive policy orientation nation states can try to orient industrial policy. This type of incitation is often mostly political communication without strong impact on industrial development.

5.1.2 A focus on vertical priorities

Significant, large scale, national strategies are in most case targeting industrial objectives rather than the development of a specific technological objective (apart from purely research oriented policies). As such, IoT centred policies are infrequent. And IoT is most often integrated as one of the technological solutions in larger scale industrial and economic policies.

As illustrated in more details in section 5.3, although the priorities vary regionally, the main IoT initiatives in Europe and globally centre around 4 strategic domains: Automotive, Smart Cities, Manufacturing and Energy.

We review below these 4 domains plus the other ones covered by the LSP programme (Health, Agriculture, Consumer IoT) to identify the reasons that can make them national priorities and point out nations in which they have been established as priorities.

5.1.2.1 Automotive

Automotive is one of the most important industry, with a global massive consumer market (that make economies of scale possible) and a strong R&D and innovation culture. It is often seen as a

strong driver for industrial development and employment and its support is thus an important part of nation states' economic policy.

It is one of the leading domains in term of digital transformation and moreover a domain in which national regulations (road safety, emissions) are frequent and important.

It is thus a domain in which national IoT initiative are developing. Unsurprisingly it appears to be a priority in the countries that have already a strong established automotive industry: the US, Germany, and in a lesser extent France, Italy or UK.

5.1.2.2 Health

Nation states have developed Health policy and research initiatives, but most often they centre around pharmaceutical research and/or the digitalization of the health industry at large without a specific focus on IoT.

As such Health doesn't appear to be a strong national IoT priority.

5.1.2.3 Smart Cities

Although Smart-Cities initiative exist locally they are very much fragmented and only a few countries have really significant, large scale Smart-Cities plans.

The main drivers for nation state to establish Smart Cities as a national IoT priority seem to be the anticipation of massive city growth due to rural exodus. The countries in which Smart Cities have been made a national IoT priority are thus mainly China and India, and in a lesser extent Brazil and Turkey.

5.1.2.4 Consumer IoT

Consumer IoT doesn't fall within the spectrum of national policies and doesn't appear to be a national IoT priority. Nation states mostly rely on the development of the IoT industry and of consumer demand to drive forward this vertical, without legislative incitation.

5.1.2.5 Agriculture

National Agriculture policy when they are developed centre more on the development of climate resilient and/or sustainable agriculture (as is the case in India with the National Initiative on Climate Resilient Agriculture or Australia's National Landcare Program's) than on IoT development. If we restrict to the EU, we must consider that any regional or national agricultural development plan must be in accordance to the Common Agricultural Policy (CAP) which already defines the room and purpose of the investments in general. Currently, IoT is considered as a tool in the development of agricultural policy but is not the priority of the policy. As such Agriculture doesn't appear to be a strong national IoT priority at the present time. However, it is expected that the new CAP that will enter into force during the period 2021-2027 will consider innovation and digitisation as a priority for the EU's agriculture and rural areas [60]. This would translate in some of the member states or regions selecting priority investments in innovative digital technologies including the IoT.

5.1.2.6 Manufacturing

The modernization of the manufacturing / industrial infrastructure is often a national priority as it is seen as a strong driver for both future growth and employment. The development of the Industry 4.0 (digitalisation of the manufacturing industry) is foreseen to reshuffle the cards of industrial production. Automation is seen as offering possibilities to relocate production in countries where labour costs have previously led to a reduction of manufacturing.

IoT plays a strong part in the digitalisation of the manufacturing industry and thus, the development of the industrial IoT can be considered a national IoT priority in several countries: Germany, China, South Korea, and in a lesser extent France, and the UK.

5.1.2.7 Energy

Energy access is considered a strategic state prerogative in most countries and national regulations have an important role in prescribing energy technology use and development. Additionally, the transformation of the energy industry (seeing more decentralized production, unpredictable consumption and a liberalized market) requires important digital solutions, namely the deployment first of smart meter infrastructure and second of a smart grid infrastructure.

As such, Energy is often the leading national IoT priorities as nation states push for the adoption of smart meters and/or the development of smart grids. This is the case for example in Italy, France, or Spain and in a lesser extent in UK, or the US.

5.2 Digitising European Industry framework and IoT developments

EC is maintaining political mobilisation of the European platform of national initiatives, encouraging national initiatives for digitising industry, monitoring implementation of actions, supporting member states to launch and maintain digitalisation strategies, and reinforcing the broader involvement of stakeholders across the EU [35]. EC monitors the state of digitalisation across the union. The Digital Economy and Society Index (DESI) shown in Figure 16 [35], indicates that EU is making progress in digitalisation. However, more efforts and investments are needed to close the gap between countries and to make the most of the digital opportunities.

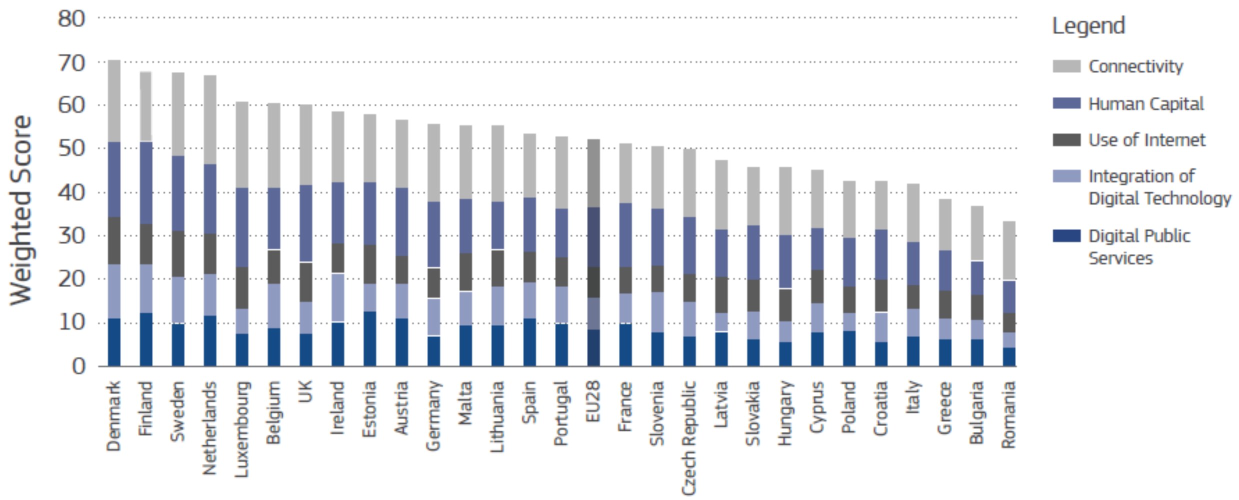


Figure 16: Digital economy and society index, by main dimensions of the DESI, (Source: EU-DEI [35])

5.2.1 The digitising European industry initiative

EC aim to get in place a "digital-friendly" regulatory framework and has put forward 45 initiatives to complete the Digitising European Industry (DEI) initiative, of which 25 are legislative proposals, (11 completed and 14 approval) [35]. Some of the most relevant key impact on the European industry are proposals on cybersecurity and free flow of non-personal data. Relations between online platforms, businesses, and liability challenges emerging from IoT and artificial intelligence (AI) will be addressed.

As part of the European Digital Single Market (DSM) strategy; the DEI initiative where presented by EC in 2016 and aims to reinforce the European competitiveness in digital technologies to ensure fully benefit from digital innovation. The DEI supports Public-Private Partnerships (PPPs) that

develop future digital technologies. The actions are structured along the following five main pillars, building on and complementing the various national initiatives for digitising industry [33][35]:

- European platform of national initiatives on digitising industry.
- Digital innovations for all: Digital Innovation Hubs.
- Strengthening leadership through partnerships and industrial platforms.
- A regulatory framework fit for the digital age.
- Preparing Europeans for the digital future.

Figure 17: The Digitising European Industry initiative's five pillars, (Source: EU-DEI [35]).

Europe has a thriving and diversified economy, including world market share of 33% in robotics, 30% in embedded systems, 55% of automotive semiconductors, 20% of semiconductor equipment and 20% of photonics components, but also challenges as [34]:

- Big differences in industry digitalisation levels across sectors, countries and regions.
- Only 20% of the companies are highly digitised.
- As much as 60% of the large industries and 90% of the SMEs feel lagging behind in digital innovation.
- Losing leadership on digital industrial online platforms.
- 44% of the population lack basic digital skills, while 90% of future jobs will require some level of digital skills.

However, digitalisation of products and services can add more than 110 billion Euros of annual revenue for industry until 2020 [34], and specific focus areas (FAs) in the H2020 programme support actions across several industrial sectors, such as digitising and IoT industry.

5.2.2 Digital industrial platforms

Like online platforms in the consumer marked, digital industrial platforms are important to place Europe in the lead of digital transformation [35]. They combine various functions implemented by different technologies via clearly specified interfaces and make data available for use by different applications. The integration of key technologies like IoT into future sector specific digital industrial platforms are important. Large-scale pilots gradually develop and mature such platforms, covering full value chains across the EU. Finally, digital industrial platforms equipped with business models establish ecosystems of different groups of market actors in versatile

marketplace. It is crucial for Europe that the industries agree on how technologies and systems can be integrated (interfaces, functions, etc.) to create new innovative products, services and markets. A flow of products and services between the companies are needed, due to few individual companies can cover the whole value chain themselves.

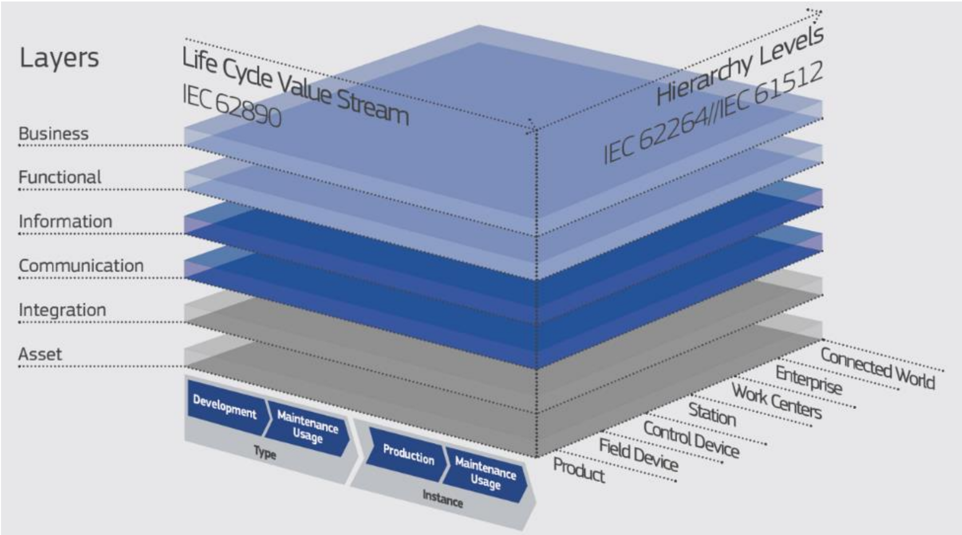


Figure 18: The Reference Architectural Model Industrie 4.0 (RAMI 4.0), (Source: EU-DEI [35]).

Digital industrial platforms offer virtual environments aiming exchange of data between different companies in a secure business ecosystem, which also requires common standards and governance rules such as Industrial Data Space (IDS) [35]. Promising digital industrial platforms will support higher levels of distribution and customisation of manufacturing processes across the value chains.

Seamless integration and interoperability will be supported by following widely accepted reference architectures, such as the Reference Architecture Model Industry 4.0 (RAMI 4.0), as illustrated in Figure 18 [35]. RAMI 4.0 facilitate common understanding through a framework to position different applications, specifications and standards with respect to each other.

Another open platform is FIWARE, a set of high-level software components, so called enablers, including specifications and open source reference implementations. FIREWARE components are already used in a wide range of industrial sectors.

5.3 National IoT initiatives across industrial sectors (including the ones cover by LSPs)

IoT finds applications in a large array of application domains, and IoT is most often integrated in national digital strategies as part of specific plans targeting vertical industries rather than independently. The targeted sectors vary from countries to others but concentrate mainly over 4 domains (Automotive, Smart City, Industry and Energy), some of which are in direct link with the domains covered by the LSPs.

This section presents important national initiatives targeting vertical sectors in selected European countries and compare them with other national initiatives worldwide.

5.3.1 Automotive

The analysis of governmental initiatives around IoT in the automotive sector can be split into 2 main categories: connected vehicles and self-driving vehicles representing the short-term and long-term vision of the digital evolution of the automotive industry. The following chart sums up the positioning of various European and non-European countries in term of national IoT initiatives relating to Automotive.

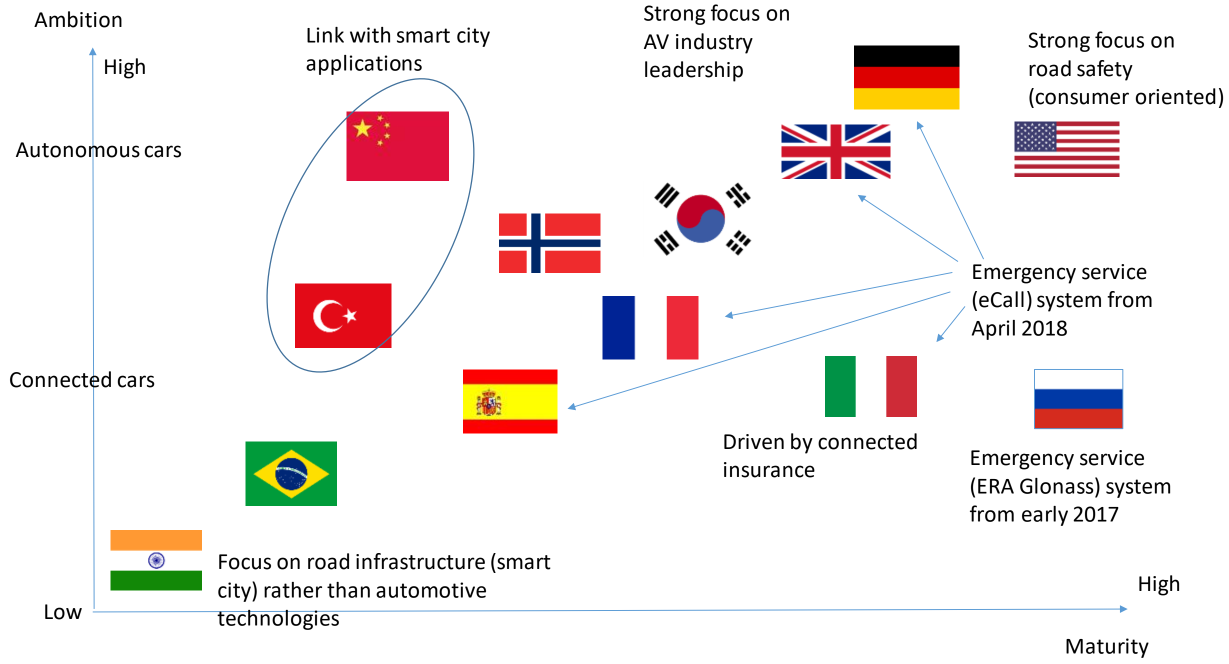


Figure 19: Main positionings of the panel countries in the automotive sector (Source: IDATE)

5.3.1.1 Connected car

The connected car market development is strongly driven by regulation.

One of the key examples is the eCall regulation, taking place in European Union. The initiative is intended to bring rapid assistance to motorists involved in a collision anywhere in the European Union. eCall was made mandatory in all new cars sold within the EU from April 2018.

The eCall initiative aims to deploy a device installed in all vehicles that will automatically dial 112 in the event of a serious road accident, and wirelessly send airbag deployment and impact sensor information, as well as Galileo coordinates to local emergency agencies. eCall builds on E112.

Russia has implemented a similar service.

Around 15 million passenger cars are newly registered each year in the EU, meaning a yearly minimum of 15 million modules' shipment, therefore making the eCall service a massive driver for this industry.

Regarding other national initiatives, we can notice some differences among countries, including the European member states where Italy is strongly driven by the connected insurance topic.

5.3.1.2 Autonomous vehicles

Autonomous vehicles are on the tracks to be a strong game changer in the coming years with massive impacts on everyone's lives and for the traditional OEMs' business model.

The future of automotive relates to the self-driving vehicles. However, for now the leading manufacturers are mainly luxury car manufacturers in a first step. To better anticipate this new paradigm, many governments have already decided to tackle this new industry transformation. Most often, leading countries on this topic are also at the forefront of the industry 4.0 topic, including Germany, and the USA mainly. Nonetheless, the approaches slightly differ. Germany and the UK focus on autonomous vehicle industry leadership (industry oriented) whereas the USA focus on road safety mainly, even though US industry including automotive manufacturers and tech companies are at the forefront of this topic.

Other countries do not really consider this topic as an emergency for them. It has to be noted that this topic is very linked to smart city around infrastructure and related mobility services provided by these next-gen vehicles, including India or even China.

5.3.1.3 Summary of National IoT initiatives related to the Automotive sector

The following table present a summary of the main Automotive related IoT national initiative in the world major economies.

Table 3: National IoT initiatives targeting Automotive (Source: IDATE)

Country	National plan	Scope	Budget (million EUR)	Timeline	Current results
Russia	National Technological Initiative - AutoNet	Telematics, smart urban mobility, logistics	162.34 for the entire NTI strategy	Long-term (2016-2035)	Projects launched and run including a large one for passenger transportation (deadline December 2018)
China	Multiple national plans including "the Implementation Plan to Promote Smart Transportation by Carrying Forward Internet Plus Convenient Transportation"	• Smart and green vehicles; • Intelligent transport infrastructure; • Mobility business model innovation; • Intelligent logistic system	During the 12th Five-Year Plan period (2011-2015), 5.8 billion EUR was invested in urban ITS, 4.5 billion EUR in highway ITS systems and 3.8 billion EUR in other areas of ITS networks	Long term 2015 - 2030	Technical research, testing and validation
US	"Connected Vehicle Program" run by the US Department of Transportation	Connected vehicles	30.275 million USD during the 2017 fiscal year	First wave in fall 2015 and second wave in 2017	Technical research and testing
South Korea	Master Plan in Preparation for the Intelligent Information Society – AV commercialization & support policy	Institution, infrastructure, technology and industry	233.2	Partial commercialization of Level 3 AV technology by 2020; Leading the trend toward Level 4 AV technology by 2026	K-City project to be open for traffic by late 2018
Brazil	-	-	-	-	-
India	-	-	-	-	-
Germany	Strategy for Automated and Connected Driving	• Connected vehicles Autonomous vehicles	80 million EUR budget for the support program for the connected and autonomous driving	Research projects up to 2020.	Technical research and testing
France	No national plan, but several initiatives and/or legislation	• Connected vehicles Autonomous vehicles	-	Testing of autonomous cars on public roads by 2019 Regulatory framework by 2022	Technical research and testing
Italy	No national plan, but push for connected insurance	• Connected vehicles (connected insurance) Autonomous vehicles	-	-	Legislation approved regarding the installation of telematics devices
Spain	Innovation Plan for Transport and Infrastructures 2018-2020	• Connected vehicles	More than 2.5 billion euros (not all for	Launched in 2017, with projects over the next 10 years	Technical research and testing

		• Autonomous vehicles New transport systems	automotive IoT projects)		
UK	Centre for Connected and Autonomous Vehicles	• Connected vehicles Autonomous vehicles	Around 100 million GBP into the R&D (between 2014 and 2017), with a further 56 million GBP coming from industry contributions.	-	Technical research and testing
Turkey	Creation of UKOME (Metropolitan Municipality Transportation Department	Gives strategic direction to the Metro, the ESHOT bus division, ferry operations, utilities and road developments	N/A	Since 2005	Digitalisation of traffic monitoring in the main/largest cities
Norway	NTP 2018-2029	Involving input from ministries, agencies, regional authorities, urban municipalities, businesses, industry and organizations	€43.5M per year for new technologies in transportation systems	2018 - 2029	-

5.3.2 Smart City

Smart city covers a wide range of applications ranging from urban mobility solutions (improve information on city mobility solutions, optimise traffic, promote alternate or multi-modal mobility solutions, etc…), to smart environment solutions (street lighting, waste collection, air pollution) or public safety initiatives (video surveillance and other surveillance tools).

5.3.2.1 Analysis of existing initiatives

The following chart sums up the positioning of various European and non-European countries in term of national IoT initiatives relating to Smart Cities.

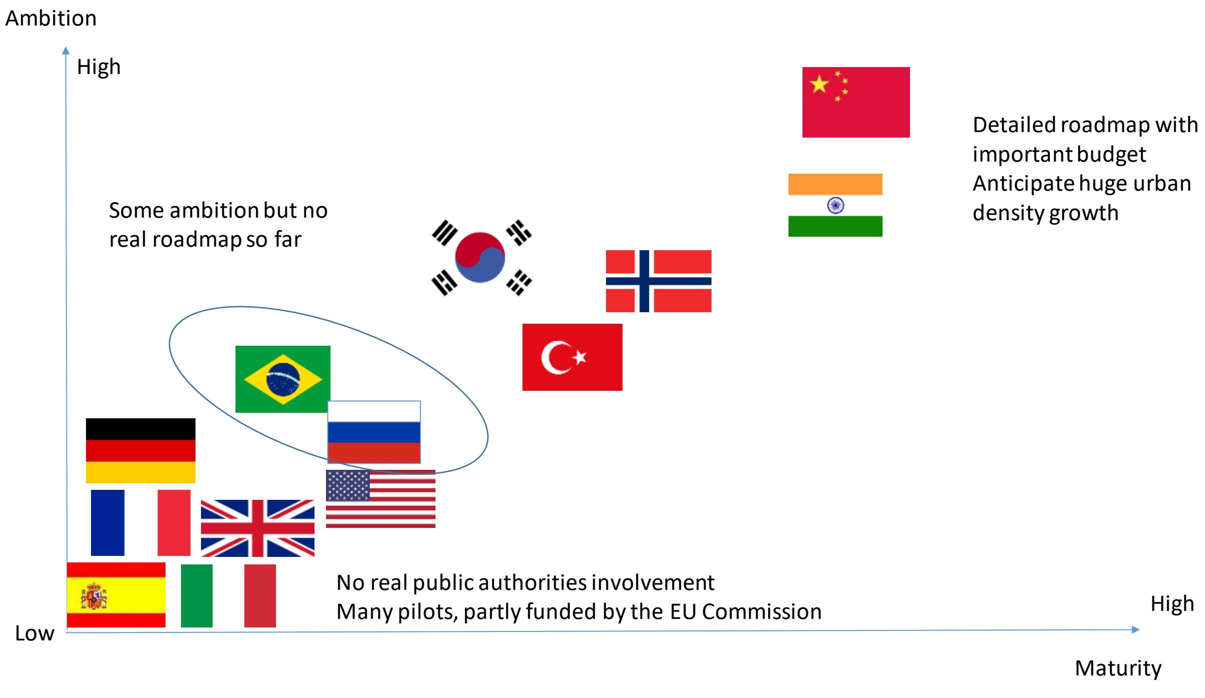


Figure 20: Main positionings of the panel countries in the Smart City sector (Source: IDATE)

The main Smart City initiatives come from developing countries that need to handle massive rural exodus in the next decades. According to UNO, almost 70% of world population will live in a city by 2050.

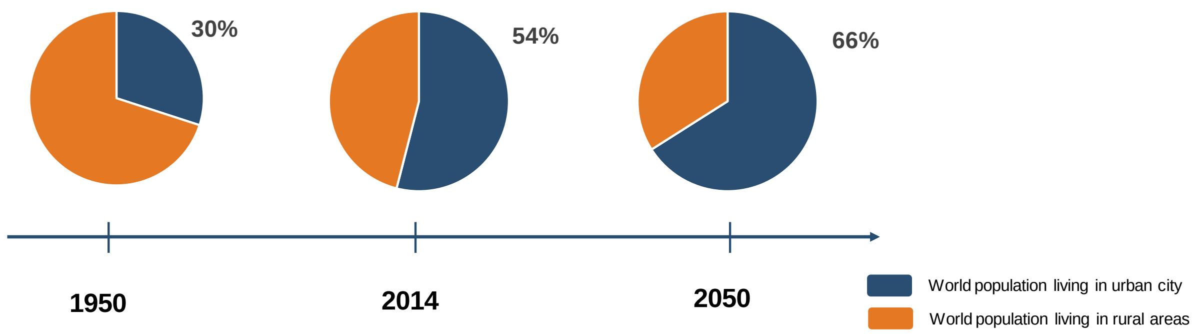


Figure 21: Evolution of the urban population over a century (Source: UNO)

Hence, many initiatives mostly refer to urban transport and mobility and related infrastructure.

In the developed countries, smart cities topic is still a buzz word but there are no real national plans driving its development.

Nevertheless, many initiatives appeared in the last decade in some cities focusing on one or two applications (mobility, environment, security).

The development and the initiative itself mainly depend on the local authorities. Furthermore, part of pilots or deployment mainly refers to smart utilities only.

5.3.2.2 Summary of National IoT initiatives related to the Smart City sector

The following table illustrates the main initiatives from the public authorities around the world regarding the development of the smart cities.

Table 4: National IoT initiatives targeting Smart City (Source: IDATE)

Country	National plan	Scope	Budget (million EUR)	Timeline	Current results
Russia	-	-	-	-	-
China	Multiple Government Guidances since 2012, of which the latest one is “New-type Smart City Plan” announced in 2016	• Intelligent information infrastructure; • Smart governmental service; • Urban public service; • Urban management; • New information economy	Public funding from the National Development Bank reached **11 billion EUR** for the period 2015 – 2018, plus other funds through Public-Private Partnership (PPP) programs	No explicitly announced roadmap regarding mid-to-long term development; A few objectives were set for 2020	During the Thirteen Five Year Plan (2016-2020), 100 New-type of Smart City will be selected
USA	-	-	-	-	-
South Korea	Global Smart City (K-City)	Safety, smart mobility, smart utilities, smart building, smart store management, smart maritime	Decided individually for each project	Ministry of Science, ICT and Future Planning (MSIP)	Busan K-City project held in 2015-2017

South Korea	U-City project	Management of gas, water and sewage, energy, transportation and building structures	Decided individually for each project	Ministry of Land, Infrastructure and Transport (MOLIT)	The Songdo U-City project to be implemented by 2020
Brazil	"Internet of Things: An Action Plan for Brazil"	Not yet defined	Not yet defined	2018-2022	Roadmap in development
India	Smart City Mission	Retrofitting, redevelopment, greenfield, Pan-city	6 000	2015-2020	99 cities selected within the Smart City Challenge by January 2018
Germany	-	-	-	-	-
France	-	-	-	-	-
Italy	-	-	-	-	-
Spain	National Plan for Smart Cities	Demonstrators for cost savings, citizens' satisfaction and new business models	188	2015-2020	25 cities implementing projects. Total investment: 77 million EUR
UK	-	-	-	-	-
Turkey	Information Society Strategy and Action Plan	Development of smart cities in Turkey (pilot tests and Living LABs)	N/A	2015-2018	N/A
Turkey	Regional Plan by the Ministry of transportation	Implementation of smart traffic light systems	N/A	2014-2023	N/A
Turkey	The Climate Change action plan	Smart Transport, smart grids, smart waste management,	N/A	2014-2023	N/A
Norway	Innovation Norway	Provide innovation policy advice to the Norwegian Ministry of Industry and Fisheries and the counties, other ministries and society	Balance sheet total at year end was NOK 24.0 billion (€2.55B)	2015-2018	N/A
Norway	Long Term Plan	better health and health services, research-based welfare policy and professional practice, knowledge-based industry throughout the country, as well as industry-relevant research	N/A	2015-2024	N/A

5.3.3 Manufacturing

Although not covered by the LSP programme, the manufacturing vertical is at the centre of many national initiatives related to IoT.

It is considered as a key vertical by many national states as it is seen as a driver for future growth, competitiveness and employment.

5.3.3.1 Analysis of existing initiatives

The following chart sums up the positioning of various European and non-European countries in term of national IoT initiatives relating to Manufacturing and Industry 4.0.

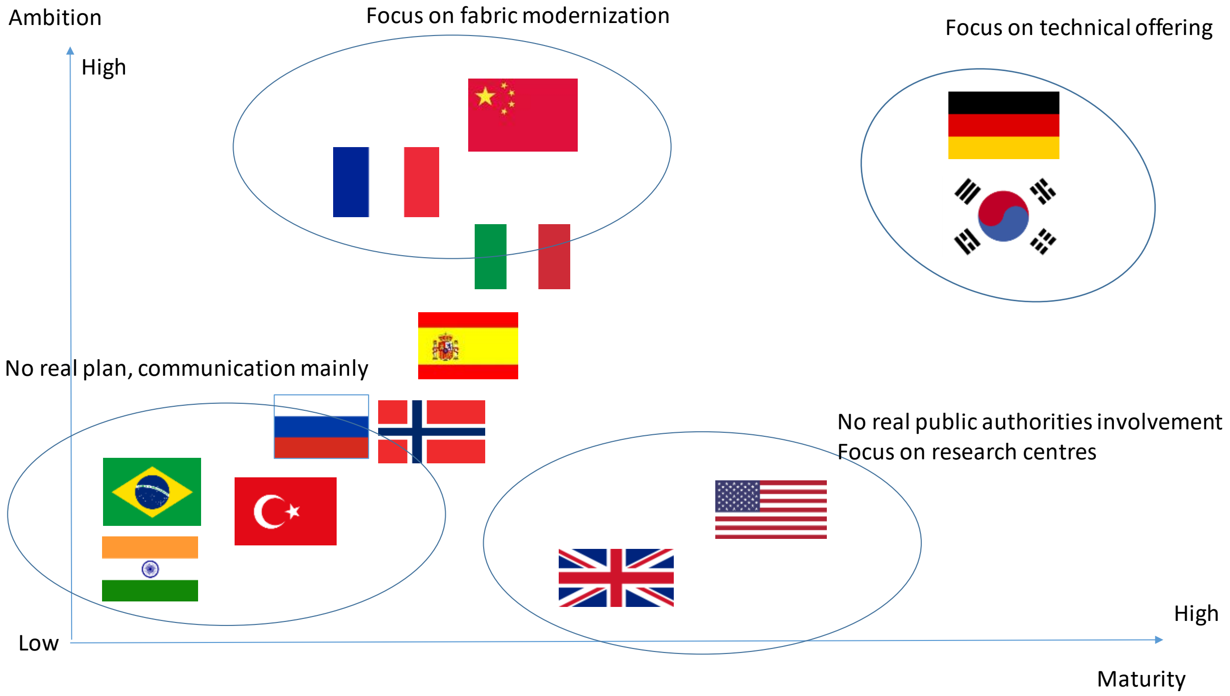


Figure 22: Summary of national initiatives in various countries in the Manufacturing sector (Source: IDATE)

The first observation is that the vision of the industry of the future is roughly the same everywhere.

All projects are based on three themes:

- Development of a technological offer based on digital technology,
- Modernization of the productive fabric
- Training/education

Some countries including Russia also point out some legislation efforts around standardization, regulation and technical norms, etc.

The main recommendations in each national initiative are very strategy-oriented and not very detailed. And for some countries, it appears that national initiatives represent more a support for political communication than a sound policy.

Nevertheless, some important differences appear, and the various initiatives can be grouped in different segments.

The programs in Germany and South Korea are very similar because they focus on developing technology offerings.

Germany is a pioneer in this field with its Industry 4.0 programme, and it is therefore seeking to leverage its assets, namely machines.

Its program consists primarily in financing and organizing research in industrial robotics and automation, with the idea of imposing norms and standards, in terms of digitization of production systems.

South Korea, which has digital giants like Samsung or LG, has also the most robotised industry in the world in 2013, with 437 robots for 10,000 employees, far ahead of Japan (323), Germany (282) or France (125).

In opposition, the French project is more like that of China. In France, the priority is above all to modernize the productive apparatus to improve competitiveness. To counter the ageing of the industrial fabric, the objective is in particular to help 2,000 SMEs to undertake a personalised diagnosis of their plants by the end of 2016.

With its plan "Made in China 2025", China has the same goal. It has to move up the range, restructure and modernize its factories while the wages of Chinese workers are soaring.

The United States and the United Kingdom have embraced a third approach. Unlike France, it is not a question of supporting business investment with a plan. The idea is rather to create research centres dedicated to key technologies, such as additive manufacturing or new materials.

Some developed countries in Europe like Italy and Spain are implementing their own Industry 4.0 plan, as well.

For the other countries, the stake is less limited. For some of them, local public authorities have not implemented any plan yet, like in India.

The scope also varies from country to country, depending on local expertise (Germany with a strong focus on automotive and industrial machines) and Russia (in aviation and aerospace).

5.3.3.2 Summary of National IoT initiatives related to the Manufacturing sector

The following table illustrates the main initiatives from the public authorities around the world regarding the development of the future of industry.

Table 5: National IoT initiatives targeting Manufacturing (Source: IDATE.)

Country	National plan	Scope	Budget (million EUR)	Timeline	Current results
Russia	National Technological Initiative (NTI) TechnoNet	Technology development and popularization, education, legislation improvement, professional community	162.34 for the entire NTI strategy	Long-term (2017-2035)	In progress
China	Made in China 2025 (MIC 2025)	10 priority sectors: • New and advanced materials; • Advanced rail and equipment; • Aviation and aerospace equipment; • Agricultural machinery and technology; • Energy-saving and new-energy vehicles; • High-end electrical and power equipment; • Information and communication technology industry; • High-end manufacturing control machinery and robotics; • Advanced marine equipment and high technology vessels;	25.6 billion EUR venture fund was planned out at the launch of MIC 2025, complemented by a number of provincial-level funds and central bank and commercial banks' lending	Long term 2015 - 2049	In 2015 and 2016, the MIIT initiated more than 200 projects for smart manufacturing at enterprise level.

Country	National plan	Scope	Budget (million EUR)	Timeline	Current results
		• Biopharmaceuticals and high-end medical apparatus and instruments			
USA	No initiative but consortia and alliances	-	-	-	-
South Korea	Manufacturing Innovation 3.0	IT and SW-based Process, Innovation Convergence, New Material, HR training	155 million EUR devoted to R&D	2014-2025	
Brazil	"Internet of Things: An Action Plan for Brazil"	Not yet defined	Not yet defined	2018-2022	Roadmap in development
India	No initiative	-	-	-	-
Germany	Industrie 4.0 (I4.0)	Digital innovation and business model transformation	200	2011-2020	Around 500 projects financed within I4.0 in 2017
France	Industrie du future (IdF)	New resources, smart cities, eco-mobility, medicine, data economy, smart food, digital confidence, smart devices	10 000 from public sources	2015-2020	3400 companies supported by 2017
Italy	Industria 4.0	Various sectors and technologies	18 000	2017-2020	Private investment increased by >10 billion in 2017 comparing to 2018
Spain	Industria Conectada 4.0	Technologies that merge physical and digital worlds, Communication and data-related technologies.	97.5 + additional 68 for ICT companies and 10 for innovative clusters	2015-2020	Innovation & research programme set up in 2016
UK	HVM Catapult	27 technologies from automation to digital manufacturing	164	2012-2018	Implementation at 123% of the target; 17 EUR generated for each 1 EUR of public funding
Turkey	Industry 4.0	Digitalisation Connectivity Future Factory	N/A	2015-2025	developing a roadmap for Industry 4.0 R&D until 2023

Country	National plan	Scope	Budget (million EUR)	Timeline	Current results
Norway	Manufuture Norway	Five pillars: 1. New added value products and services 2. New business models 3. Advanced Industrial Engineering 4. Emerging manufacturing science and technologies 5. Infrastructures and education	N/A	2015-2024	developing a roadmap for Industry 4.0 R&D until 2023
Norway	Long term plan	Key components of the Industry 4.0 are: • Cyber Physical Systems (CPS), • Internet of Things (IoT), Internet of Services (IoS), • Smart Factory.	(€70.18M) in the 2015 fiscal budget +€42.53M by 2018 to increase appropriations to research infrastructure +€42.53M by 2020 for good Norwegian participation in the EU Framework Programme	Long-term (continuous)	N/A

5.3.4 Energy

Similarly, to the manufacturing sector, the Energy domain, although not covered by the LSP programme should be considered while looking at national IoT initiatives as it's a domain in which many important initiatives exists and in which regulation acts as a strong driver for technological adoption.

5.3.4.1 Analysis of existing initiatives

The following chart sums up the positioning of various European and non-European countries in term of national IoT initiatives relating to Energy.

The main national initiatives targeting the energy domain cover usually two aspects:

- Smart metering which aims to replace existing mechanical meters with smart and communicating meters. Smart metering concerns every kind of utilities such as water, gas and electricity.
- Smart grid which is often seen as the next step of smart metering. Smart grid remains an electricity topic.

As mentioned previously, the regulation and the related public policies remain the main driver of the introduction of IoT in the energy sector, across the world.

These regulations allow this sector to be the leading vertical in the IoT markets, in volume. Today, the public polices focus strongly on connected meter migration, notably in the EU. Because it is the pre-requisite for smart grid implementation,

For instance, the EU aims to replace at least 80% of electricity meters with smart meters by 2020 wherever it is cost-effective to do so. This smart metering and smart grids rollout can reduce emissions in the EU by up to 9% and annual household energy consumption by similar amounts.

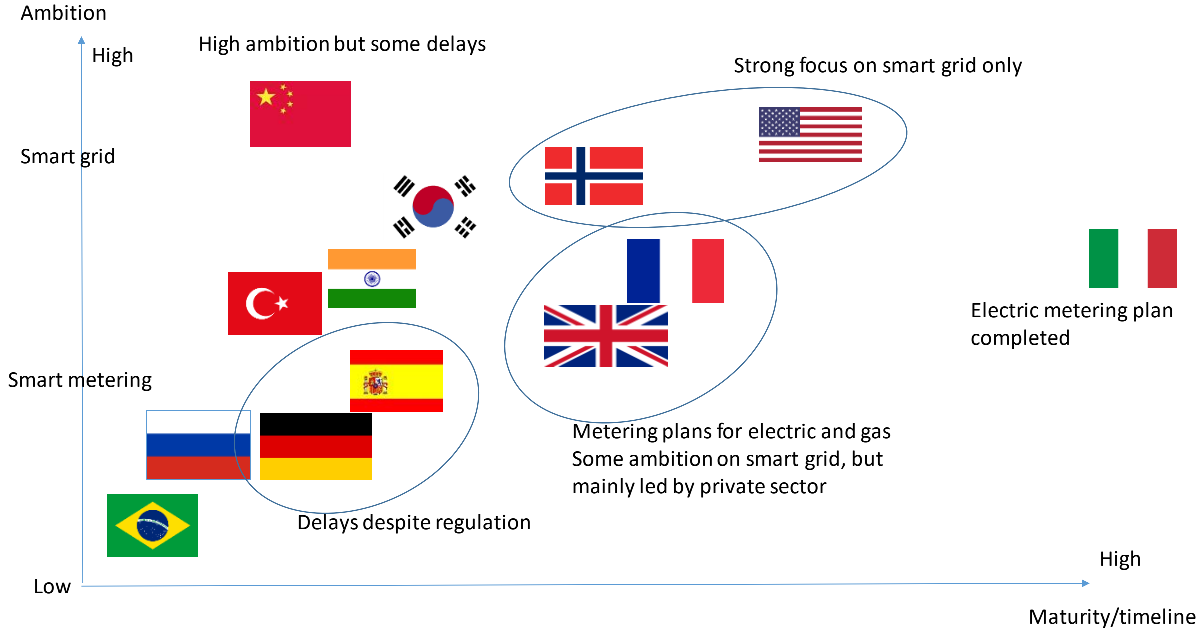


Figure 23: Summary of national initiatives in various countries in the Energy sector (Source: IDATE.)

Regarding the benchmark per se, we see different groups in terms of public authorities' ambition (assuming smart grid is a further step) and maturity.

- China unveiled very high ambition around StateGrid strategy, but the rollout has just begun, and it will take time, considering the population.
- US and Norway have very high ambition on smart grid where the national authorities really focus on.
- UK and France are well engaged in smart metering rollout, claiming to meet deadlines. Plus, they have launching some projects and pilots regarding smart grid deployment.
- Spain and Germany are less advanced regarding rollout, Germany do not expect to meet EU deadline and Spain haven't planned a gas deployment yet.
- Other countries like Russia, India have elaborated a long-term plan.
- Brazil seems to not have prepared a plan yet.

5.3.4.2 Summary of National IoT initiatives related to the Energy sector

The following table shows an overview of main national IoT initiatives related to Energy in the selection of countries.

Table 6: National IoT initiatives targeting Energy (Source: IDATE)

Country	National plan	Scope	Budget (million EUR)	Timeline	Current results
Russia	National Technological Initiative (NTI) - EnergyNet	Sustainable & flexible networks, smart distributed energy, consumer services, Complex solutions	162.34 for the entire NTI strategy	Long-term (2016-2030)	Several large pilot projects running; R&D and educational programs launched

Country	National plan	Scope	Budget (million EUR)	Timeline	Current results
USA	Smart Grid Investment Grant (SGIG) Program	Customer segments, Advanced Metering Infrastructure (AMI), Electric distribution & transmission	2 770	2010-2015	Implemented
USA	Smart Grid Demonstration Program (SGDP)	32 projects for Smart Grid Regional Demonstrations & Energy Storage Demonstrations	479	2010-2016	Implemented
Korea	Master Plan in Preparation for the Intelligent Information Society - Smart Grid Initiative	Smart Place, Smart Transportation, Smart Renewables, Smart Electricity Service, Smart Power Grid	2930	Long-term (2012-2030)	Some large projects are run such as Jeju Smart Grid Test-Bed
Brazil	"Internet of Things: An Action Plan for Brazil"	Not yet defined	Not yet defined	2018-2022	Roadmap in development
India	National Smart Grid Mission (NSGM)	Electric distribution, transmission; standards and regulations	243.3 with 83.3 from the federal budget	39M smart meters by 2019	In progress
France	Linky	Electric meters communicate through PCLs	The 35 million Linky meters to be installed by 2021 will cost a total of **€4.5 billion**	95% rollout by 2020	France is late on the roll-out of smart electricity meters as 2.1 million meters are installed instead of the targeted 2.5 million in 2016
France	Gazpar	Meters for gas	Meters will cost around 1 billion euros, financed by an increase in the tariff representing €2 per year on the customers over the duration of the project.	95% rollout by 2020	As of 2017, 4% of the meter fleet has been deployed
Germany		Smart metering	N/A	2020	The German authorities plan to replace only 15% of the meters for electricity with smart ones by 2020 Germany is late on its digitalisation

Country	National plan	Scope	Budget (million EUR)	Timeline	Current results
					process due to cost concerns
UK	Replacement of 100% of the traditional meters	both electricity and gas meters	£11 billion	2020	As of 31 March 2018, there were a total of 21.16 million gas meters and 25.42 million electricity meters operated by large energy suppliers in domestic properties across Great Britain.
UK	Smart Grid Forum	Smart grid	£23-27 billion will need to be spent between now and 2050	2018-2050	-
Italy	Replacement of 100% of the traditional meters	Electric meters	Enel invested €2 billion in installing 34 million meters	The rollout of smart meters was completed in Italy since 2011 after 10 years of deployment. According to Enel's roadmap, the plan is now to reengineer the meters in order to upgrade the system by 2021	Italy has already reached those objectives of the latest regulation come from the European Commission.
Italy	Italgas	Gas meters	$4.4 billion project	to install four million smart meters in the retail gas market and 20,000 for large industrial consumers by 2020	-
Spain	Replacement of 100% of the traditional meters	Electric meters	No public funding (apart from the EU). The projects are financed privately or paid by the users	2011-2018	The roll-out of smart meters in Spain is DSOs-led and the deployment programmes vary in smart meters capabilities.

Country	National plan	Scope	Budget (million EUR)	Timeline	Current results
Spain	FutuRed	Smart grid	The private sector is investing in smart grid development and R&D to promote increased competitiveness for Spanish utility providers	-	Some specific projects so far
China	Internet Plus Smart Energy Action Plan	• Smart energy infrastructure; • Demand-side management; • Data-associated applications; • Synergy with other sectors; • Industrialization and standardization	5.2 billion EUR by the end of 2017; The mid-to-long run financing plans is not disclosed yet	Middle term (2016-2025)	In 2017, 55 demonstration projects across 23 regions or cities were planned out to develop their regional models of the Energy Internet implementation
Turkey	NEEAP	• Reduction of technical and non-technical energy losses.	N/A	2023	-
Turkey	Turkey Smart Grid	• Pilot project for the large-scale implementation of a national smart grid		2023	All DISCOs (distributors) have to report by 2020 to the Energy Market Regulatory Authority (EMRA) about their specific needs and the technologies that they want to implement for smart metering.
Norway	No nationwide plan from the government	• Smart metering	-	-	local and foreign private actors compete for the roll out of smart meters with different means and using different solutions.
Norway	Demo Norway	• National Smart Grid demonstration and laboratory platform with eight real power system demo sites	Not available	2014-now	More than 10.000 network customers with Smart meters connected
Norway	ECOCITY	• Demonstration of innovative integrated energy concepts for supply and demand.	Not available	2005-2012	Many of the activities are carried on beyond the project.

6. IoT across Strategic Research and Innovation Agendas

6.1 Overview of IoT research and innovation topics across European initiatives and related to IoT architecture layers

One of the main objectives is to coordinate and align the SRIA (Strategic Research and Innovation Agenda) at the European level with the developments in the different European initiatives and align with the global trends. Some initiatives are described below in alphabetic order.

6.1.1 5G

5G is the next generation of mobile standards, extending 4G performances to new use cases. The main innovations of 5G are software/IT based and are implemented to bring more dynamism to the mobile infrastructure. 5G differs from previous mobile standards by a willingness to address vertical industry and machine type communications (i.e. IoT) needs from the onset.

Regarding the *network communication layer*, the research addresses the fundamental change is the explosion of IoT involving M2M communications. IoT implies a much larger number of terminals with a more diverse range of requirements than human-held terminals require. This poses huge technical challenges to many areas of the communication network. The research focuses on new effectively network control solutions driven by network function virtualization (NFV) and software defined networks (SDN) for authentication, addressing, routing, etc. Radio systems providing both high capacity and very low traffic solutions including low latency, low energy and high indoor penetration. The network development is based on multi radio access technologies, including new technologies like millimetre wave, small cells, massive MIMO (multiple-input and multiple-output) to exploit multipath propagation, beam steering, and possibly non-orthogonal carriers. Research areas for terahertz communications such as transceivers, antennas and solid-state circuits are also addressed.

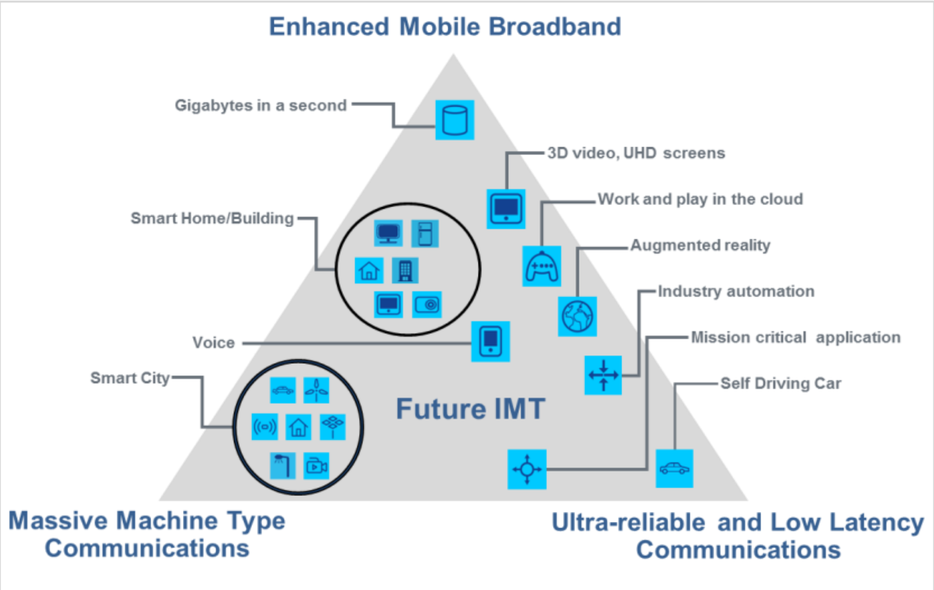


Figure 24: Scenarios for 5G communications (Source: Nokia)

5G aims to address three different types of scenarios, the latter two of which are directly linked with IoT applications: (i) Enhanced Mobile Broadband (eMBB) with increased speeds. The targeted applications include virtual reality and augmented reality applications (eHealth, industry),

on-board media consumption (automotive, transport), (ii) Massive Machine-Type Communication (mMTC) with a high density of connected IoT products, for use in vertical industries. The targeted applications include smart city, monitoring of energy access and distribution networks, asset tracking, telematics, predictive maintenance, connected goods, and (iii) Ultra-Reliable and Low-Latency communication (uRLLC) for guaranteed quality of service, guaranteed reliability and extremely reliable latency, especially for IoT devices. The targeted applications include automated cars, robotics, remote operation, fault prevention and alert, energy grid monitoring and control.

5G is a communication network targeting the IoT, and the main scenarios for 5G communications are illustrated in Figure 24.

6.1.1.1 5G strategy in Europe

In Europe the main instrument developing and implementing the 5G strategy is the 5G Industry Association and the 5GPPP. The 5G PPP is leading 5G R&D efforts at the European level and pulling together initiatives between all players (MNOs, vendors, universities).

On 17 December 2013, the European Commission signed a landmark agreement with the ‘5G Infrastructure Association’, representing major industry players, to establish a Public Private Partnership on 5G. The 5G Infrastructure PPP (5G PPP) is a joint initiative between the European ICT industry and the European Commission. The 5G PPP is planned to be organised in three or four phases, encompassing research (125 million EUR investment), optimisation (Phase 2 the current phase since autumn of 2017) and large-scale trials (2019-2020). It aims to deploy 5G as from 2020. It is intended to leverage the EC investment. Ideally, private investment should reach five times the amount that the EC is putting on the table, bringing the total investment into the 5G PPP to 3.5 billion EUR.

5GPPP Working Groups:

Within the 5G PPP there are a number of working groups, where the work of projects and other stakeholders can converge for the identification of shared issues and development of supported program level positions on technical and strategic items.

The following picture present a vision of the established working groups, their origins and subjects.

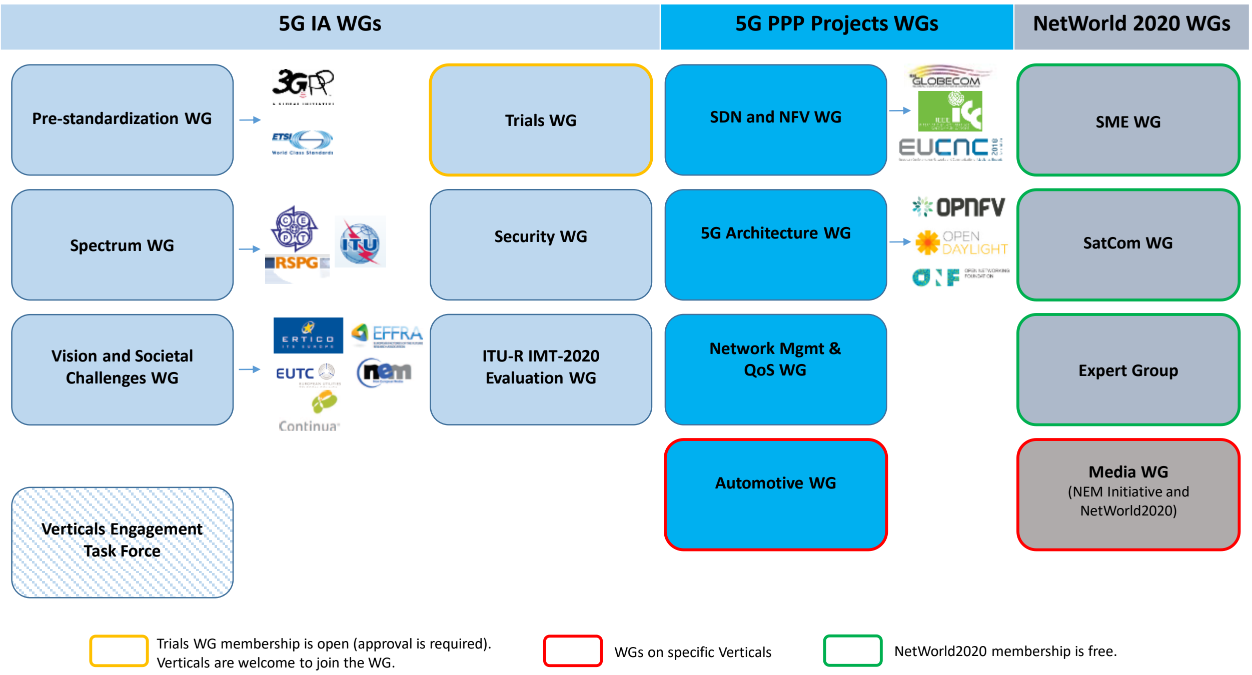


Figure 25: Working groups 5GPPP

Some of these working group topics are related to the work carried out in the LSP programme and in the Activity Groups, such as:

- The Security working group, targeting 5G Security topics and vision.
- The Trials working group, which concentrate on 5G deployment trials by the projects with scenarios including IoT topics.
- The vision and societal challenges working group, which aim to identify the societal, economic, environmental, business and technological benefits obtainable from the realisation of 5G main concepts (including the massification of IoT deployments)
- The 5G Architecture working group which facilitates discussion between 5G PPP projects developing architectural concepts and components.
- The 5G Automotive working group which focuses on connected and automated mobility and serves as a common platform between 5G PPP projects developing V2X and Vehicle-as-Infrastructure concepts and components.

Phase 2 projects:

Some of the Phase 2 projects are targeting trials that are directly linked to some of the application domains targeted by the LSP programme, specifically: health, automotive and smart city. The following table present a list of some of the most relevant trial envisioned in phase 2 projects.

Table 7: Relevant 5GPPP Phase 2 projects.

Activity Domain	Project and Trial	Brief UC Description(s)
Automotive	5GCAR - Lane Merge	The lane merge use case deals with the automated creation of gaps for cars entering a lane, using cellular communication and a centralized lane merge coordination. In the planned setup, a fixed camera installation near the intersection is used to also detect vehicles that are not connected, and thus cannot receive instructions or communicate their location and intentions.
Automotive	5GCAR - Cooperative Perception for Manoeuvres of Connected Vehicles	Cooperative perception is enabled by a combination of V2V and V2I communication, using both 5G and 4G simultaneously. 5G provides low-latency V2V communication based on camera streaming overlaid with sensor information.
Automotive	5GCAR - Vulnerable Road User Protection	A car and a VRU (modelled as a small chassis with wheels carrying all the needed equipment) are each equipped with a portable hardware prototype continuously transmitting 5G positioning signals to the network infrastructure, which is used for accurately positioning the car. On top of that, a 4G network is used for exchanging real-time location information and warning messages, to avoid collisions. A display in the vehicle depicts relevant objects such as other cars or pedestrians, showing a visual alert in case of a critical situation. The VRU may be equipped with such a display as well. Additionally, an acoustic warning may be provided inside the car and to the VRU.
Automotive	5G TRANSFORMER - Intersection Collision Avoidance (ICA)	The purpose of the ICA system is to alert drivers about the existence of any possible obstacles and eventually activate the emergency braking system. The communication infrastructure facilitates a real-time exchange of data between the involved entities.
Automotive	5G TRANSFORMER - See-through	Thanks to the cooperation between vehicles, streaming information is provided to all the vehicles that want/need to access to it. This information can be used to identify potential obstacles that cannot be detected through on-board sensors.
Automotive	ONE5G - Automotive Proof-of-Concept	Automotive Industry - Tele-operated driving - Assisted/cooperative/autonomous driving

Health	SLICENET - 5G eHealth Smart / Connected Ambulance Use Case	The Connected Ambulance will act as a connection hub for the emergency medical equipment and wearables, enabling real-time streaming to the awaiting emergency department team at the destination hospital. This use case will advance the emergency ambulance services by developing new collaborative models with the healthcare stakeholders to help create improved experiences and outcomes for patients in their care. Both single and multi-patient scenarios will be explored to maximise the impact of 5G technology on patient care.
Smart City	5GCity – Use case 1 Unauthorized Waste Dumping Prevention	This use case is focused on monitoring through HD video surveillance systems some urban areas under the risk of environmental abuse due to unauthorized dumping of waste materials. HD video cameras will be installed in a specific waste collection island that will be monitored H24. Use of (real time) video analytics app will allow smarter control procedures, including the possibility to trigger (real time) alert procedure to the Municipal Officers, which are the closest to the monitored point. We plan to use deep neural networks for the detection part. The use case is being developed in the City of Lucca (Italy).
Smart City	5G-MoNArch - Touristic City	Haptic internet Augmented and virtual reality, public deployment of a 5G network. The touristic city testbed demonstrates a selected set of innovations on the topic of network slicing and elasticity. In particular, computational elasticity to improve the utilization efficiency of computational resources by adapting the NF behaviour to the available resources without impacting performance significantly, orchestration-driven elasticity by re-allocating NFs within the heterogeneous cloud resources located both at the central and edge clouds, and slice-aware elasticity for serving multiple slices over the same physical resources while optimizing the allocation of computational resources to each slice based on its requirements and demands
Smart City	MATILDA - Smart City Intelligent Lighting System Use Case	This use case regards a smart city service provided by Orange Romania based on a developed middleware for smart cities services. The considered service in MATILDA regards an intelligent lighting system. The intelligent lighting system is a smart city application that runs over a LoRaWAN network and enhances the lighting company in the city to easily manage and maintain all the lighting poles in a city while achieve energy consumption reduction up to 70% when combined with full LED lamps.
Smart City	NGPaaS - IoT4energy	IoT infrastructure can fully control end-to-end deployment of Energy-based IoT Applications by provisioning and allocating resources on-demand according to initial SLAs or evolving SLAs. Main VNFs & Applications of Interest are Real-time automation, Smartgrid, SLA monitoring, Multiple-application management. The main stakeholders are Utility Companies, Facility Managers, Property Managers.
Smart City	ONE5G - Smart-Megacity Proof-of-Concept	Media and Entertainment and eOffice: - Outdoor hotspot with Immersive/Virtual Reality, collaborative gaming, Ultra-High-Fidelity Media capabilities - Live Event Experience – massive number of users with video sharing Smart Cities, Smart Utilities and Energy: - Traffic/pollution management, surveillance, stream management and city automation

6.1.1.2 Timeline and availability

An important point to consider in seeking alignment between the IoT and 5G SRA is the global timing of 5G research, standardization and deployment.

2020 is the 3GPP/ITU deadline for the 5G standard. 2017 will see early 5G trials in the USA. 2018 is expected to be the 5G kick-off year with first field 5G tests and 5G showcase at several major

international sport events. The following picture present a general timeline of standardization and international activities.

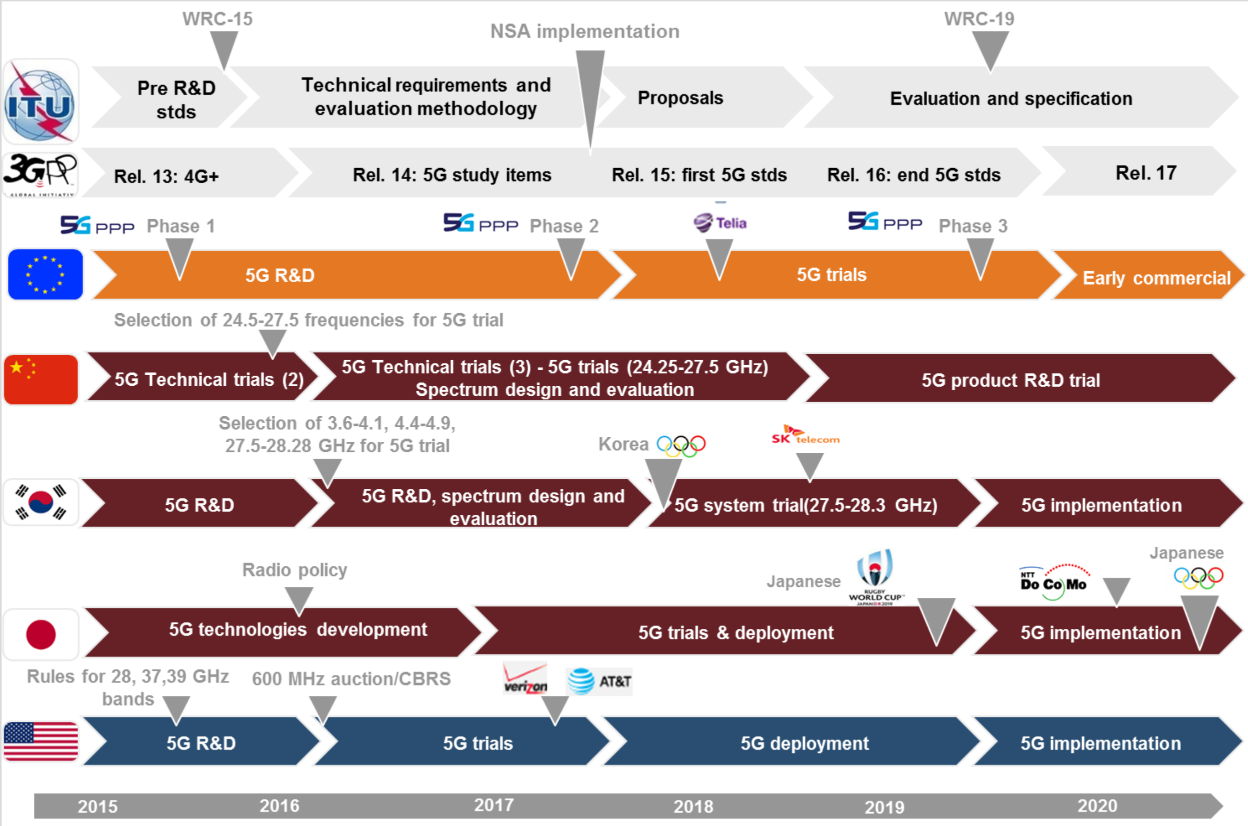


Figure 26: Scenarios for 5G communications (Source: IDATE [59])

However, and despite this willingness to address the IoT applications in the 5G design, the initial deployment of 5G are likely to concentrate on fixed wireline access and then on eMBB use case closer to the traditional use of mobile network than to IoT applications. The massive MTC and ultra-reliable low latency communication features of 5G are likely to be available only in a more distant timeframe (2025).

6.1.2 ECSEL

Regarding the *physical layer*, semiconductor process technology and integration actions focusing on introduction of materials, devices and new concepts, in close collaboration with the equipment and materials community, to allow for the diversity of compute infrastructure needed, from high performance, over mobile and edge computing to ultra-low power data processing at IoT node level. The usage of heterogeneous multi-core architectures is still poorly addressed at software level (OS, compilers, tools), and demands new solutions for computing architectures including multi-core processors suitable for cyber-physical applications.

For the *network communication layer*, is including wireless energy transmission concepts for short range applications, adapting IoT devices in different environments, using specific requirements for sensors and actuators (environmental conditions, energy management, communications, etc.).

The analysis of huge amount of data from billions of IoT devices is expected and a challenging the *processing layer*. Connectivity enables functions and functionalities to be performed at all levels, such as distributed computing, edge-computing or fog computing. Avoiding unnecessary data processing and communications are a key challenge to energy efficiency. Quality of Service (QoS) in real-time requires heterogenous parallel processors, new memory architectures, parallel oriented programming languages and design methods in the solutions. Relevant information needs to be extracted and patterns recognized and allow for security and privacy. Machine learning

techniques and cyber-physical systems seamless integrated in IoT concepts and different applications (IoE, IoB, IoV, etc.) are addressed.

6.1.3 ECSO

ECSO is the industry-led contractual counterpart to the European Commission (EC) for the implementation of the Cyber Security Contractual Public-Private Partnership. The main objective of ECSO is to support all types of initiatives and projects that aim to develop, promote, encourage European cyber security. Particularly aims to foster and protect from cyber threats the growth of the European Digital Single Market (DSM) [46]. Further, ESCO is instrumental in providing support to the EC for a new certification scheme. ECSO members include large companies, SMEs and Start-ups, research centres, universities, clusters and association, users and operators, as well as European Member State's local, regional and national administrations, countries part of the European Economic Area (EEA) and the European Free Trade Association (EFTA) and H2020 associated countries.

The cybersecurity domain addresses *all layers* of the IoT architecture and addresses the various technology areas ICT, Cloud, Mobile etc. that fit into the IoT architecture. Specifically, on the IoT architecture, ECSO is addressing this as a new emerging technological area (others also being addressed are Quantum Computing, embedded systems and smart grids etc.).

ECSO have identified, Identity and Access Management (IAM) as an area that will be challenged by IoT with its extended range of needs created by the increased mixture and scale and distribution of devices brought on by IoT, machine-machine and man-machine interactions. Additionally, it is noted, that in promoting trust, it is always desirable not to depend on a single authority, but also take into account decentralized trust models such as blockchain [30].

Importantly, ECSO see that end users need to clearly understand and manage the level of security delivered by different providers and to further control the degree of their identification.

To trust in digital services, the end users need to be empowered to be able to make informed decisions, and therefore these calls for methodologies not only to focus on security and privacy by design but also trust. To target this, the whole lifecycle from development to operation needs to be properly addressed by key steps including certification, distribution and deployment.

Within ECSO Working Group 1 (WG1) on Certification, Standardization, Labelling and Supply Chain Management (launched in October 2016), ECSO have focused a lot of effort on analysing SOTA and industry challenges for creating an EU ICT security certification framework proposal [40]. ECSO liaise with the EC in this WG and contribute to the European ICT security certification framework proposal. ECSO propose a meta-scheme approach that does not re-invent the wheel with new certification schemes, but rather integrates existing best standard and national schemes. It further proposes an EU label to indicate the various assurance levels that the framework uses to integrate different certification schemes and certifies all areas from individual components, products, and services through to the organisations. It must be noted that not all schemes fit all scenarios which is very relevant in the creation of a meta-scheme framework.

ECSO continue to collaborate with ENISA in providing detailed suggestions on the European Cyber Security Certification Framework supported by concrete studies in IoT, smart meters, SCAD etc.

According to the latest vision from ENISA [32], regarding the framework it is proposed to subdivide the market into different areas including:

- Critical and high-risk areas
- Widely deployed digital products and
- Low-cost mass-market products such as the IoT.

In accordance to this, ECSO considers three types of IoT devices depending on the application and security requirements:

- Consumer: IoT addressing the mass market requiring light-weight trust and security guarantees.
- Industrial: IoT for the digitisation and automation of industrial processes.
- Critical infrastructure: IoT deployed in critical infrastructures demanding a high degree of trust and security.

In summary, ECSO are identifying challenges for IoT such as authentication and authorization but the main priority is in the establishment of a trustworthy IoT framework, and this is being realized through the WG1 activities EU ICT security certification framework.

6.1.4 euRobotics

The *physical layer* focus on sensor and actuators for assistive robots obtain information from the ambient and embedded systems around them and act accordingly, either from data collected by smart sensors or by other smart devices in the environment. Sensing devices connected to protocols and standards for enhancing exchanging data between multiple devices.

The *network communication layer* includes technologies for robots to communicate with each other, other IoT devices and internet-based services in the cloud. This real-time communication needs to be automatized and standardized. In view of the increasing complexity of robotics systems, communication protocols and code generation tools are needed, which allow to easily design flexible topologies of sensors and actuators and to automatically generate and configure the code for their communication. Address wireless communication protocols, particularly ad-hoc protocols and mobile to mobile systems for robot communication.

The research regarding the *process layer* address areas from ontological learning to phylogenetic and social learning. Formal methods for knowledge integration also on a collaborative way with other robots. Complete description of mechatronic behaviour by merging mechanical and electrical modelling methods with computer science modelling methods and virtual validation of the system. IoT integration of robots and making use of big data methods and semantic web technology (Industry 4.0). The processing layer involve modelling and knowledge engineering for system development with the extension of object modelling through computer vision or sensing (infrared, tactile, etc.), database of typical motion and interaction patterns during care processes, at a format that allow care personnel to verify correctness of learnt models

The *storage layer* address unstructured and unknown environments that assistive robots are likely to face through processing carried out in the cloud, (e.g. the recognition of novel objects, advice about strategies or decision making that may involve clinical judgement that cannot be pre-programmed or the interpretation of social context). Complex interpretation of interaction tasks processed and stored in the cloud where drivers/enablers can be collated from a wider range of experience. Establishing standards for these high level cognitive and social interactions will be critical to their wide spread enhancement of assistive robots. Interacting between products by different manufacturers will be critical to wide adoption and deployment.

6.1.5 FoF/EFFRA

There is an increasing interest on adoption of new enabling technologies. The *physical layer* addresses the challenges regarding IoT, M2M, low power systems, and smart embedded system integrations in manufacturing and maintenance to enable innovation in factory environments.

Concerning the *network communication layer* research is needed to develop new software solutions to monitor and improve products' energy efficiency throughout their usage. New enabling technologies such as smart embedded systems, IoT, low-powered sensors, and M2M

integration in manufacturing and maintenance are needed. Integrated data collection solutions and analysis tools based on advances in IoT for energy consumption at each step of the life cycle are explored. The research is focusing on using advanced IoT equipped sensors to transfer product specific data to monitoring logic hosted in cloud infrastructure, and the usage of mark-up language to easily decipher product patterns, and anonymization techniques.

The *abstraction layer* work focus is on solutions that ensure interoperability between objects and systems operating at the shop floor, addressing challenges as semantic operability, research on IoT and product traceability, unique product identifiers, transactional purchase and consume models, semantic search functionality, and third party added values. Integrated backend enterprise systems for inventory/asset tracking and intuitive mobile user interfaces to visualise/browse the entire range of available services/products.

Interoperability issues of different factory processes by research and standardization of interfaces are important topics concerning the *service layer*, for example development of IoT solutions gaining device/middleware integration (inherently scalable and distributed) supporting self-configuration capabilities that limits manual intervention. Research on dynamic object-oriented models to represent classes and instances of real-world resources as well as semantics representations to model intangible assets on the shop floor. Platform interoperability and semantic interoperability are key technology challenges addressed.

Regarding the *application layer*, future research should use advances in IoT technology and product traceability to map unique product IDs against corresponding service offerings, to develop transactional customer purchase models, and to add semantic search functionality to correlate product, after sales services to third party added value services. Continuous IoT based data collection from the field and along the value chain in conjunction with appropriate simulation and data analytics tools to identify deviations between expected and actual results allowing early management of factory and production issues.

Manufacturing 2.0 enterprise assets and products of the future will affect the concept of the IoT where objects carry information about themselves, communicate with each other and the environment. Regarding the *collaboration and processes layer*, new research should bridge the gap between different abstractions of objects operating at the shop floor level, business systems level, and at the level of supply networks. On the shop floor level, the need for research and standardisation of interfaces includes both mechanical and digital interfaces. For faster fault resolution and triggering repair options, cooperating objects that carry their own servicing and maintenance information are addressed. Scalable tracking/tracing of production orders, assets, products and personnel across different organisations; semantic modelling/description of IoT resources; capturing non-deterministic/unpredictable behaviour at run time; and business process modelling should be researched.

7. CONCLUSIONS

7.1 Contribution to overall picture

This work gives and overview of the IoT landscape in Europe and contributes to coordination and alignment with strategic research and innovation agendas, including developments in the different national and European initiatives aligned with the global trends.

Through the IoT European Large-Scale Pilots Programme, CREATE-IoT and the LSPs contribute to strategic activity groups (AGs) that were defined to foster coherent implementation of the different LSPs. The coordination is implemented by creating AGs that address IoT topics of common interest across the LSPs. Analysing the different LSP use-cases and identifying similarities, dissimilarities, and trends for common utilization for the community. The major development trends in IoT application areas are identified. The demand and supply sides are analysed individually, together with market pull and technology push balancing, and common high-level considerations. Research and innovation efforts in specific IoT topics ensure the long-term evolution of the IoT.

7.2 Relation to the state-of-the-art and progress beyond it

The IoT may be entering a critical phase in its market/user acceptance, but at the same time new market opportunities opens due to the technology developments encourage new interactions, solutions, services and business models in the future. The main drivers behind the development of IoT are the emerging wireless IoT technology make near real-time communication possible anywhere for anyone and anything. The available bandwidth is increasing due to efficiency improvement of the communication technology. Small sensors for data collection, decreasing power consumption and development costs, at the same time power efficient data processing units increase their computing capacity. And the scalability properties increase and opens enhanced big data collection supported by edge computing. Coordination of focus areas and alignment of activities across different domains are necessary to succeed in the future.

Some of the key topics affecting the European IoT market scenario are the continued importance of privacy and security with IoT, 5G driving the mobile IoT, the evolution of IoT platforms, artificial intelligence (AI) and edge computing integration, digital twins' representations, Blockchain and IoT, and data monetization and IoT-driven new business models. For instance, there are high expectations in terms of AI analytics impact, but the use of AI techniques is still in an early stage and most of the European IoT adopters are not actively using analytics as part of their IoT deployments. The increased opportunities of collecting, transmitting and using data also arise important privacy and security issues which are highly important in a future perspective.

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