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IoT European Large-Scale Pilots – Integration, Experimentation and Testing

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Abstract

The IoT European Large-Scale Pilots Programme includes the innovation consortia that are collaborating to foster the deployment of IoT solutions in Europe through the 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 programme projects are targeted, goal-driven initiatives that propose IoT approaches to specific real-life industrial/societal challenges. They are autonomous entities that involve stakeholders from the supply side to the demand side, and contain all the technological and innovation elements, the tasks related to the use, application and deployment as well as the development, testing and integration activities.

This chapter describes the IoT Large Scale Pilot Programme initiative together with all involved actors. These actors include the coordination and support actions CREATE-IoT and U4IoT, being them drivers of the programme, and all five IoT Large-Scale Pilot projects, namely ACTIVAGE, IoF2020, MONICA, SynchroniCity and AUTOPILOT.

8.1 IoT European Large-Scale Pilots Programme

The scope of the IoT European Large-Scale Pilots Programme is to foster the deployment of IoT solutions in Europe through the 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. Specific pilot considerations include:

- Mapping of pilot architecture approaches with validated IoT reference architectures such as IoT-A enabling interoperability across use cases.
- Contribution to strategic activity groups that were defined during the LSP kick-off meeting to foster coherent implementation of the different IoT Large-Scale Pilots.
- Contribution to clustering their results of horizontal nature (interoperability approach, standards, security and privacy approaches, business validation and sustainability, methodologies, metrics, etc.).

The IoT European Large-Scale Pilots Programme includes projects addressing the IoT applications based on European relevance, technology readiness and socio-economic interest in Europe. The IoT Large-Scale Pilot projects overview is illustrated in Figure 8.1, and the areas addressed by the projects are listed below.

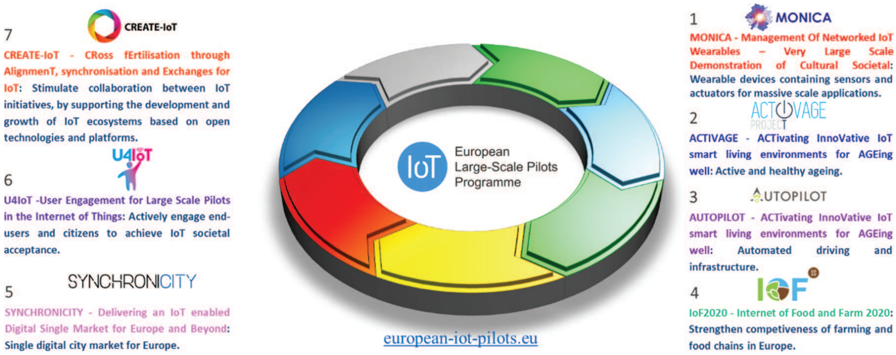


Figure 8.1 IoT European Large-Scale Pilots Programme Projects Overview.

Research and innovation effort in specific IoT topics ensure the longer-term evolution of Internet of Things and the IoT European Large-Scale Pilots Programme projects are addressing:

- The integration and further research and development, where needed, of the most advanced technologies across the value chain (components, devices, networks, middleware, service platforms, application functions) and their operation at large scale to respond to real needs of end-users (public authorities, citizens and business), based on underlying open technologies and architectures that may be reused across multiple use cases and enable interoperability across those.
- The validation of user acceptability by addressing, in particular, issues of trust, attention, security and privacy through pre-defined privacy and security impact assessments, liability and coverage of user needs in the specific real-life scenarios of the pilot.
- The validation of the related business models to guarantee the sustainability of the approach beyond the project.

The IoT Large-Scale Pilots make use of the rich portfolio of technologies and tools so far developed and demonstrated in reduced and controlled environments and extend them to real-life use case scenarios with the goal of validating advanced IoT solutions across complete value chains with actual users and proving its socio-economic potential.

Support actions provide consistency and linkages between the pilots and complement them by addressing horizontal challenges critically important for the take-up of IoT at the anticipated scale. These include ethics and privacy, trust and security, respect for the scarcity and vulnerability of human attention, validation and certification, standards and interoperability, user acceptability and control, liability and sustainability.

The projects together form the IoT European Large-Scale Pilots Programme and a coordination body ensures an efficient interplay of the various elements of the IoT Focus Area and liaises with relevant initiatives at EU, Member States and international levels. The coordination is implemented by the creation of Activity Groups that are addressing topics of common interest across the Large-Scale Pilots.

8.2 ACTIVAGE – Activating Innovative IoT Smart Living Environments for Ageing Well

ACTIVAGE is a European Multi Centric Large-Scale Pilot on Smart Living Environments. The main objective is to build the first European IoT ecosystem across 9 Deployment Sites (DS) in seven European countries (see Figure 8.2), reusing and scaling up underlying open and proprietary IoT platforms, technologies and standards, and integrating new interfaces needed to provide interoperability across these heterogeneous platforms. This ecosystem will enable the deployment and operation at large scale of Active and Healthy Ageing IoT based solutions and services, supporting and extending the independent living of older adults in their environments, and responding to real needs of caregivers, service providers and public authorities.

8.2.1 Introduction

Throughout Europe and all around the world, mortality rates have fallen significantly over the past decades [1] leading to considerable changes in the age distribution of societies [2, 3]. In this context, people aged 60 are now expected to survive an additional 18.5 to 21.6 years and soon the world will have a higher number of older adults than children. This transformation is expected to continue, with the age group of elders (65+) growing from 18% to 28% of the EU population by the year 2060. Furthermore, according to the 2015 Ageing Report [4], 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 challenge for European countries as they must find ways to do more with less. Citizen empowerment and incitation to self-equip is one of the explored options.

Figure 8.2 ACTIVAGE Deployment Sites in 7 EU countries.

All of the aforementioned findings, highlighted the Active ageing and independent living activities (such as the EIP Action Group C2 – action plan) as the final goals for EU initiatives related to older adults [5].

Thus, legislation, technology, and reimbursement charges, enforce the health and social care systems to improve the way they are providing services to the European citizens. The "Active and Healthy Ageing" (AHA) community is wide and heterogeneous in terms of needs, demands and living environments [6]. AHA services based on the Internet-of-Things are promising to be a strategic component to support the creation of ecosystem able to dynamically answer and prevent the challenges faced by the health and social care systems [7] (H&SCS): the "always-connected" paradigm is becoming a way of life, and this could result in a positive transformation for H&SCS who are looking for new ways to reorient the provision of care and keep older people active and independent for longer.

8.2.2 Project Description

8.2.2.1 Main concepts in ACTIVAGE

ACTIVAGE is designed as ONE multi-centric Large-Scale Pilot across Europe. ACTIVAGE brings UNITY of objectives, evaluation methodologies, co-operation to achieve critical mass, and a single European platform to create and share evidence. Deployment Sites (DS) join clusters of stake-holders in the Active and Healthy Living value network, working together within a geographical space (a city or a region). These clusters or AHA-Business Ecosystems are mainly composed by a cohort of users (older adults, formal and informal caregivers), service providers; health care/social care administration; technological infrastructures and technology providers (infrastructure, sensors, applications, etc.).

DSs will deploy Reference Use Cases (UC) (see Figure 8.3) that address specific end-user needs, to improve their quality of life and autonomy. A single common interoperable ACTIVAGE IoT Ecosystem Suite (AIOTES) will be built up that provides every DS with the capacity to develop standard and interoperable IoT ecosystems on top of legacy IoT platforms, or communication and data management infrastructures. GLOCAL Evaluation Framework (Local KPIs and global KPIs) will be designed and implemented to demonstrate and evaluate health & social outcomes and socio-economic

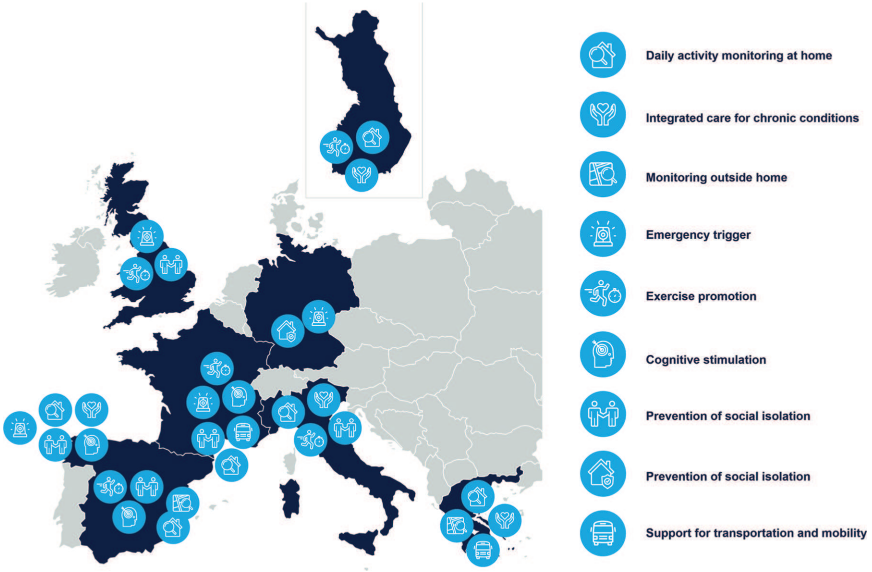


Figure 8.3 ACTIVAGE uses cases distribution.

impact from local up to a European scale, enabling effective exchange of experiences and cooperation among peers (e.g. users, providers, policy makers). 9 DS rolled out in 7 countries to constitute a major breakthrough to sustain open innovation in AHA field.

8.2.2.2 Targeted users and user needs

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. One of the most accepted measurement scales in different studies in Europe and World Wide is the Clinical Frailty Scale [8]: ACTIVAGE will concentrate on IoT solutions for older people classified under categories 1 to 5: "Very fit", "Well, Managing well", "Vulnerable" and "Mildly frail". ACTIVAGE will focus on deploying IoT 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.

ACTIVAGE focusses on "domains of needs" for the support of the older population and in order to create a demand-driven experience on the basis of

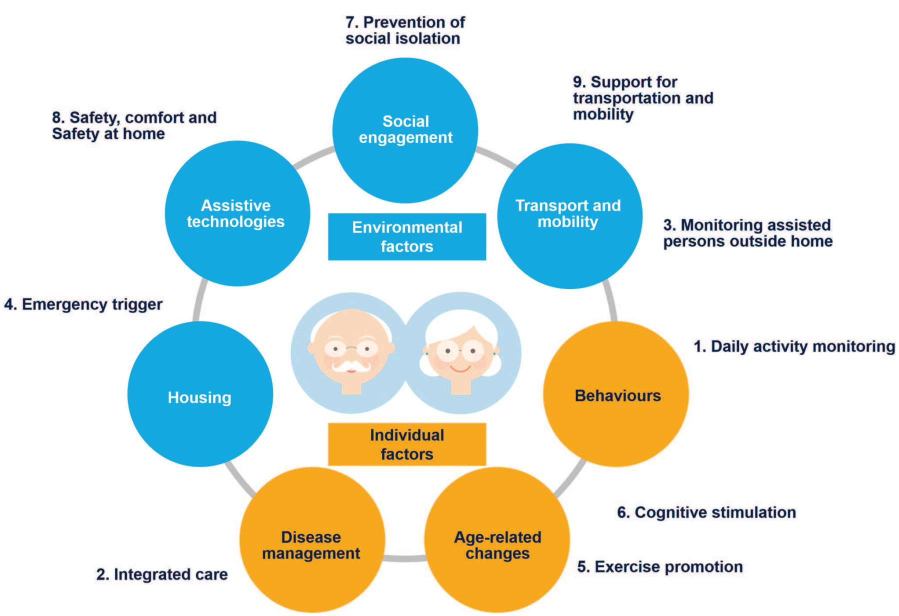


Figure 8.4 Mapping of needs and use cases.

the reference Ageing Well initiatives around the world. Figure 8.4 shows the domains of needs (on circles) and the Use Cases (UC) that will be deployed in the 9 DS involving up to 7,000 users.

8.2.3 The ACTIVAGE Model of IoT Ecosystem for Active and Healthy Ageing

ACTIVAGE is committed to build the first European AHA-IoT Ecosystem which is modelled as a technological infrastructure of hardware-software-services and standard protocols i.e. the "ACTIVAGE AIOTES", and a constellation of stakeholders interacting with each other within a governance framework towards the achievement of common goals.

Figure 8.5 shows this conceptual scheme. Data is the core asset of the ecosystem. Private Data is produced by wearable and medical devices and smart sensors and devices in their living environments (e.g. home, car, public spaces, etc.). Public data might come from different sources, not necessary linked to user interactions (e.g. weather, public services time tables, etc.). Personal/private data might be processed at the edge and at cloud level. If appropiate, interoperability interfaces are provided, enabling the delivery of a huge amount of data to be channeled across the pipeline and eventually feed hundreds or thousands of services for senior people, providers and payors.

The realization of this model is accomplished in ACIVAGE by the AIOTES: this is comprised of two layers that form all the necessary

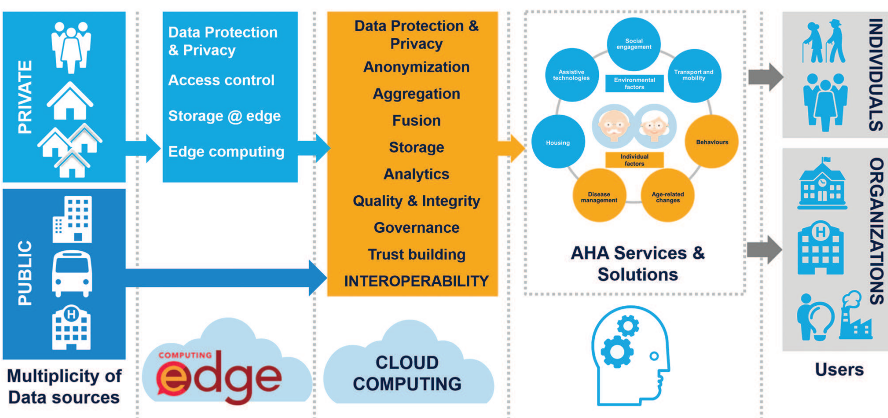


Figure 8.5 Model of AHA-IoT ecosystem.

components for: a) the support of a universal interoperability framework for the integration of the widest possible spectrum of platforms in the area of Active and Health Living and b) the formation of the diverse application marketplace and a set of application tools for the support of creators in the development and deployment phases of new applications. Figure 8.6 summarizes the envisioned architecture. The final architecture will be in compliance with standardisation projects such as IoT-A. The ACTIVAGE system will be separated into two distinct layers.

The IoT Interoperability Layer is aiming to efficiently and effectively integrate a wide spectrum of open and commercial platforms and IoT devices, having as a starting point the platforms provided for the ACTIVAGE and the IoT devices used in the Deployment Sites as shown in Figure 8.6. This layer will be further separated into two frameworks that will create standardized interfaces for a) the sharing of data with sensors and devices and b) the interoperability of their offered services. The Services Layer will include a number of functionalities to support efficient integration and effective deployment of new services to the envisioned ecosystem: the Applications Support Tools and the Marketplace.

8.2.4 Expected Project Impacts

The ACTIVAGE project has established a set of strategic impacts aligned with the vision of the project and designed to drive the activities across the project:

- **Societal impact:** ACTIVAGE may create evidence that support how AHA services based on IoT improve the quality of life of older adults, supporting the long-term sustainability and efficiency of health and social care systems. Aligned with this impact, ACTIVAGE may give answer to users' empowerment with the control of their data, safety and wellness, promoting healthy and active ageing, while enhancing the competitiveness of EU industry through new business models and expansion in new markets.
- **Innovation impact:** ACTIVAGE may ignite the economic growth by influencing the strategic decisions of the different stakeholders, offering a value based proposal built by the co-creation of the different stakeholders' views and interest. Only a valuable proposal with an integral multi-stakeholders commitment will assure the following key aspects: a) public and private investment by health and social care makers,

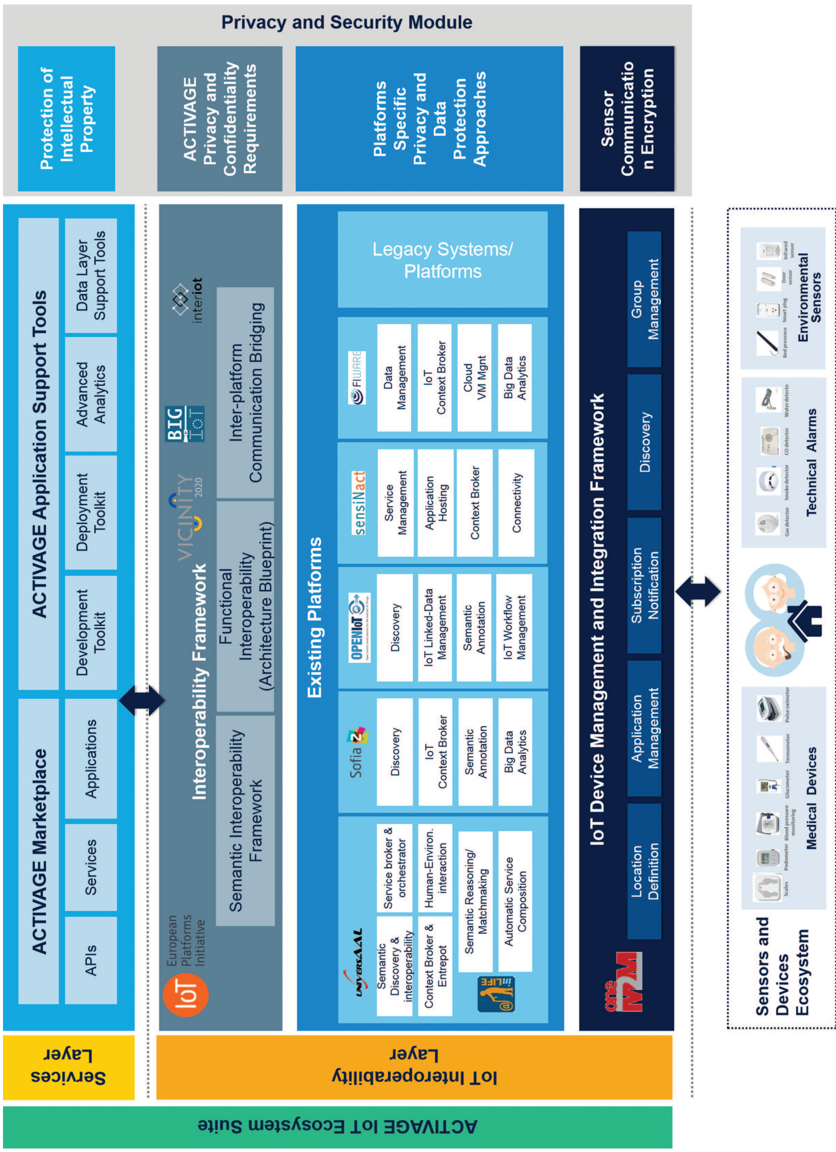


Figure 8.6 Conceptual architecture of AIOTES.

b) service providers adoption of cost-effective business models, c) senior citizens involvement in the creation and adoption of AHA services, d) to foster industrial innovation on IoT, wearables and sensor technologies and support standards for interoperability, and e) creation of new reliable and useful AHA solutions and services by SMEs and entrepreneurs.

- **Economic impact:** ACTIVAGE project may analyse the potential saving and contributions to the sustainability of the health care and social systems, and the readiness and maturity of the IoT technologies and ecosystem to host local solutions and to import and replicate solutions from other providers/location focused on value-based criteria.

8.2.5 Summary

During its 42 months duration the project will be aligned along a single five phase innovation path. After evaluating and demonstrating evidence and value to stakeholders in local Use Cases (UC), DSs will cooperate bilaterally or tri-laterally, allowing coherent, complementary replication of UC, to generate evidence on the value of interoperability and standardisation at a European scale. In the last phase, DSs will open to European external actors to incubate new UCs, technologies, solutions and Business Cases. Open calls will attract entrepreneurs and start-ups to implement innovative solutions using the mature DS's IoT ecosystem for testing, demonstration and initial market take-up.

8.3 IoF2020 – Internet of Food and Farm 2020

The Internet of Things (IoT) is expected to be a real game changer that will drastically improve productivity and sustainability in food and farming. However, current IoT applications in this domain are still fragmentary and mainly used by a small group of early adopters. The Internet of Food and Farm 2020 Large-Scale Pilot (IoF2020) addresses the organizational and technological challenges to overcome this situation by fostering a large-scale uptake of IoT in the European food and farming domain. The heart of the project is formed by a balanced set of multi-actor trials that reflect the diversity of the food and farming domain. Each trial is composed of well-delineated use cases developing IoT solutions for the most relevant challenges of the concerned subsector. The project conducts 5 trials with a total of 19 use cases in arable, dairy, fruits, vegetables and meat production. IoF2020 embraces a lean multi-actor approach that combines the development of Minimal Viable Products (MVPs) in short iterations with the active involvement of various stakeholders. The architectural approach supports interoperability of multiple use case systems and reuse of IoT components across them. Use cases are also supported in developing business and solving governance issues. The IoF2020 ecosystem and collaboration space is established to boost the uptake of IoT in Food and Farming and pave the way for new innovations.

8.3.1 Introduction

IoT is a powerful driver that is expected to transform the entire farming and food domain into smart webs of connected objects that are context-sensitive and can be identified, sensed and controlled remotely [9–11]. IoT will be a real game changer in agriculture that drastically improves productivity and sustainability. This vision is illustrated by the story in Figure 8.7, which is an

March 2020, a field somewhere in Europe

The morning mist soaks into thick shreds across the country, above the sun rises and turns the horizon red. From the fog a soft humming sound, two tractors emerge. When he spots me, the driver of the second tractor steps out, but where is the driver of the first tractor? There is none, says the farmer, I operate both machines. How? Well, that strange vehicle you saw here last week has mapped the whole field and this map is now instructing the board computers of the two tractors how to drive. The first tractor exactly follows pre-programmed lines and carries out soil cultivation, based on soil composition. My tractor with a sowing machine automatically follows the same lines and automatically adjusts distance, quantity and variety of potato seed. Incredible, isn't it?

Two weeks later…

The same field. An unmanned small tractor drives with a high speed along the same invisible straight lines. With surgical precision, a hoe eliminates every weed in the field, the farmer says. This saves a lot of chemicals and labour in comparison to earlier days where we had to spray the full field with a heavy tractor. So this is good for the environment and I have much less costs! Within a few weeks the fertilizer will follow the same lines again and by a pre-defined task map it knows exactly where and what to put different types of fertilizer for optimal growth of the plants. That map was generated on the basis of big data analysis and calculations in the cloud involving relevant data from the market, weather and public regulations. Additional cameras are checking the crop and, if necessary, make corrections. Again, the plants just get enough nutrients to grow optimally and nothing is spoiled to the environment. Wow, amazing! Come, I'll show you how it works in the office. Don't you have to stay with your tractor? Oh no, it knows what it is doing.

At the office with a good old-fashioned cup of coffee…

Of course we farmers are still in charge of our own farm but most of the field operations are carried out automatically by autonomous objects. Now we can focus on the market choices and take care of communication with our customers and last but not least citizens who are very much involved in farming nowadays. After execution of the field work, the measured data is automatically returned from the machine to the office through the cloud. This is the basis for subsequent tasks. But I also provide it to research institutes, which feed these data into computer models for further improvement. The same holds for public legislation and certification bodies. They use the same data to check for compliance to their rules. Every organisation has access to a specific set of our data in the cloud. Of course, this is subject to strict security and privacy rules. No, no, I don't want leave my data lying around. Oh yes, by the way, food safety and traceability is not an issue anymore; it is highly guaranteed by all kind of sensors and in case something might go wrong early warning systems alert me in time.

Figure 8.7 Illustrative story of the vision on IoT in agriculture.

example for arable farming, but it is exemplary for other subsectors such as dairy, meat, vegetables, and fruits including wine and olives.

To make this vision come true much technology is already available, although there are specific IoT challenges in this sector. Agri-Food ‘things’ are often living objects and attached devices have to work in harsh environments, while network connectivity in rural areas can be challenging. In fact, a large-scale uptake of IoT in agriculture is in particular prevented by a lack of interoperability, user concerns about data ownership, privacy and security, and by appropriate business models that are also suitable for (very) small companies [12, 13]. Consequently, current IoT applications in farming and food are still fragmentary and mainly used by a small group of early adopters, despite the great world-wide interest of IoT technology providers and investors.

IoF2020 is a European Large-Scale Pilot (LSP) on IoT for Smart Farming and Food Security. Its main objective is to foster a large-scale uptake of IoT in the European farming and food domain. This will contribute to a next huge innovation boost and consequently to a drastically improved productivity and sustainability in the agri-food domain. More specifically, IoF2020 aims to:

- Demonstrate the business case of IoT for a large number of application areas in farming and food;
- Integrate and reuse available IoT technologies by exploiting open architectures and standards;
- Ensure user acceptability of IoT solutions in farming and food by addressing user needs, including security, privacy and trust;
- Ensure the sustainability of IoT solutions beyond the project by validating the related business models and setting up an IoT Ecosystem for large scale uptake.

The IoF2020 consortium consists of 71 public and private partners from 16 different countries and has a total budget of 35 M€. The project started in January 2017 and will last for 4 years.

8.3.2 Trials and Use cases

The heart of the project is formed by a balanced set of multi-actor trials that reflect the diversity of the food and farming domain, including different agricultural sub sectors, conventional and organic farming, early adopters and early majority farmers, SMEs and large industrial companies, and different supply chain roles including logistics and consumption. Each trial is composed of well-delineated use cases that together address the most relevant challenges for the concerned subsector. The use cases follow a demand-driven philosophy in which IoT solutions for specific business needs are developed by a dedicated team of agri-food end users and IoT companies (integrators, app/service developers, infrastructure/technology providers) with a clear commercial drive, supported by R&D organisations. IoF2020 conducts 5 trials with a total of 19 use cases in arable, dairy, fruits, vegetables and meat production (Figure 8.8).

The ***Internet of Arable Farming (trial 1)*** integrates operations across the entire arable cropping cycle combining IoT technologies, data acquisition (soil, crop, climate) in growing and storage of arable crops (potatoes, wheat and soya beans). These will be linked to existing sensor networks, earth observation systems, crop growth models and yield gap analysis tools and external databases (e.g. economic/environmental impact) and translated into farm management systems. The trial will result in increasing yields, less environmental impact, easier cross-compliance and product traceability and more use of technology by farmers. The trial consists of 4 use cases:

1.1 *Within-field management zoning*: defining specific field management zones by developing and linking sensing- and actuating devices with external data;

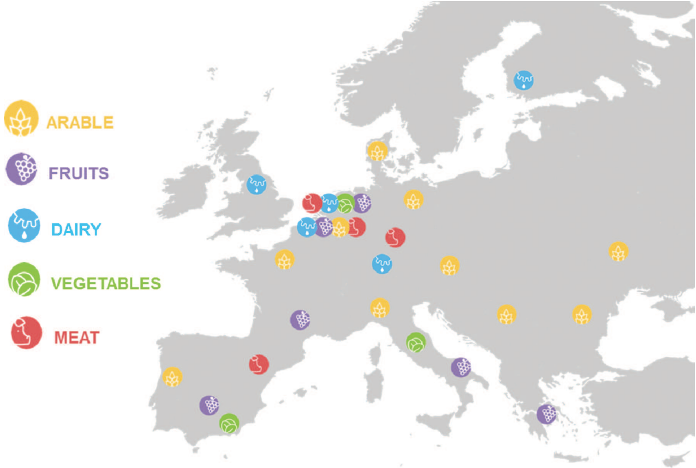


Figure 8.8 Geographical coverage of the IoF2020 trials and use cases.

1.2 *Precision Crop Management*: smart wheat crop management by sensors data embedded in a low-power, long-range network infrastructure;
1.3 *Soya Protein Management*: improving protein production by combining sensor data and translate them into effective machine task operations;
1.4 *Farm Machine Interoperability*: data exchange between field machinery and farm management information systems for supporting cross-over pilot machine communication.

The ***Internet of Dairy Farming (trial 2)*** implements, experiences and demonstrates the use of real-time sensor data (e.g. neck collar) together with GPS location data to create value in the chain from 'grass to glass', resulting in more efficient use of resources and production of quality foods, combined with a better animal health, welfare and environment implementation. The trial focuses on feeding and reproduction of cows through early warning systems and quality data that can be used for remote calibration and validation of sensors and consists of 4 use cases:

2.1 *Grazing Cow Monitor*: monitoring and managing the outdoor grazing of cows by GPS tracking within ultra-narrow band communication networks;
2.2 *Happy Cow*: improving dairy farm productivity through 3D cow activity sensing and cloud machine learning technologies;
2.3 *Silent Herdsman*: herd alert management by a high node count distributed sensor network and a cloud-based platform for decision-making;
2.4 *Remote Milk Quality*: remote quality assurance of accurate instruments and analysis & pro-active control in the dairy chain.

The ***Internet of Fruits (trial 3)*** demonstrates IoT technology that is integrated throughout the whole supply chain from the field, logistics, processing to the retailer. Sensors in orchards and vineyards (incl. weather stations, multispectral/thermal cameras) will be connected through the cloud and used for monitoring, early warning of pests and diseases and control (e.g. variable rate spraying, selective harvesting). Traceability devices (incl. RFID, multidimensional barcodes) and smart packaging allows for condition monitoring during storage, processing, transportation and on the shelves. Big data analyses will further optimize all processes in the whole chain. This will result in reduced pre- and post-harvest losses, less inputs, higher (fresh) quality and better traceable products (incl. protected designation of origin, PDO). The trial consists of 4 coherent use cases:

3.1 *Fresh table grapes chain*: real-time monitoring and control of water supply and crop protection of table grapes and predicting shelf life;
3.2 *Big wine optimization*: optimizing cultivation and processing of wine by sensor-actuator networks and big data analysis within a cloud framework;
3.3 *Automated olive chain*: automated field control, product segmentation, processing and commercialisation of olives and olive oil;
3.4 *Intelligent fruit logistics*: fresh fruit logistics through virtualization of fruit products by intelligent trays within a low-power long-range network infrastructure.

The ***Internet of Vegetables (trial 4)*** focuses on a combination of environmental control levels: full-controlled indoor growing with an artificial lighting system, semi-controlled greenhouse production and non-regulated ambient conditions in open-air cultivation of vegetables. It demonstrates the automatic execution of growth recipes by the intelligent combination of sensors that measure crop conditions and control processes (incl. lighting, climate, irrigation and logistics) and analysis of big data that is collected through these sensors and advanced visioning systems with location specification. This will result in improved production control and better communication throughout the supply chain (incl. harvest prediction, consumer information). The trial consists of 4 use cases:

4.1 *City farming*: value chain innovation for leafy vegetables in convenience foods by integrated indoor climate control and logistics;
4.2 *Chain-integrated greenhouse production*: integrating the value chain and quality innovation by developing a full sensor-actuator-based system in tomato greenhouses;
4.3 *Added value weeding data*: boosting the value chain by harvesting weeding data of organic vegetables obtained by advanced visioning systems;
4.4 *Enhanced quality certification system*: enhanced trust and simplification of quality certification systems by use of sensors, RFID tags and intelligent chain analyses.

The ***Internet of Meat (trial 5)*** demonstrates how the growth of animals (individual and group level) can be optimized and communication throughout the whole supply chain can be improved based on automated monitoring and control of advanced sensor-actuator systems. The data generated by events will also be used for early warning (e.g. on health status) and improve the transparency and traceability of meat throughout the whole supply chain. This will assure meat quality, reduce mortality, optimize labour and improve animal health and welfare leading to reduction of antibiotics. The trial consists of 3 use cases:

5.1 *Pig farm management*: optimise pig production management by interoperable on-farm sensors and slaughter house data;
5.2 *Poultry chain management*: optimize production, transport and processing of poultry meat by automated ambient monitoring & control and data analyses;
5.3 *Meat Transparency and Traceability*: enhancing transparency and traceability of meat based on an monitored chain event data in an EPCIS-infrastructure.

8.3.3 Technical Architectural Approach

Each use case will be an autonomous implementation of an IoT system, which provides a dedicated solution for a specific domain challenge. However, for a large scale uptake it is important to maximize synergies across multiple use case systems. Therefore, a core concept of IoF2020 is that the use case systems function as nodes in a software ecosystem [14]. As a consequence, much attention is paid to ensuring the interoperability of multiple use case systems and the reuse of IoT components across them. Figure 8.9 shows the architectural approach to achieve this during design, development, implementation and deployment.

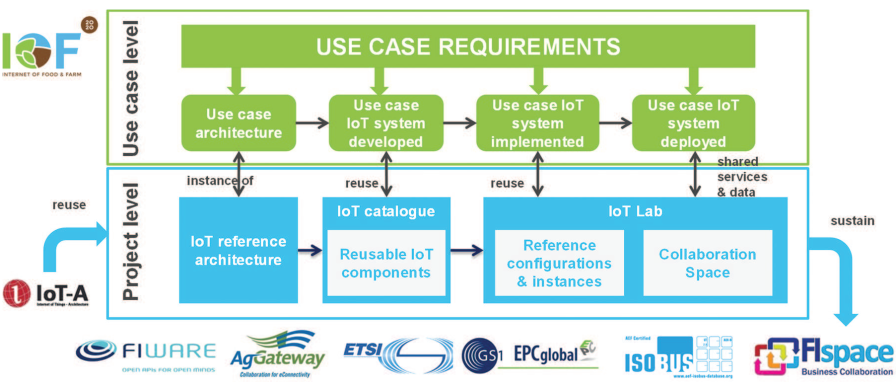


Figure 8.9 The IoF2020 architectural process to ensure reuse and interoperability of use case IoT systems.

The use case architectures will be based on a common technical reference architecture to create a shared understanding and to maximize synergies across multiple use case systems. Each use case within a trial will design a specific instance of the reference architecture to address its specific user requirements. The project will provide a catalogue of reusable system components, which can be integrated in the IoT systems of multiple use cases to facilitate large-scale uptake. This repository goes beyond a checklist and includes practical guidelines and implementation tools. The IoF2020 lab will support the implementation of reusable IoT components in a testbed environment. Finally, IoF2020 will provide a Collaboration Space in which services and data can be shared as a key enabler to facilitate the interaction between the IoT systems of the use cases during deployment. As indicated, the project will reuse components and knowledge from previous projects and existing organizations and try to embed and sustain the project results into the same organizations.

8.3.4 Lean Multi-Actor Approach

IoF2020 embraces a demand-driven methodology in which end-users from the agri-food are actively involved during the entire development process aiming at cross-fertilisation, co-creation and co-ownership of results (see Figure 8.10).

The approach for the use cases is a combination of the *lean start-up methodology* that focuses on the development of Minimal Viable Products

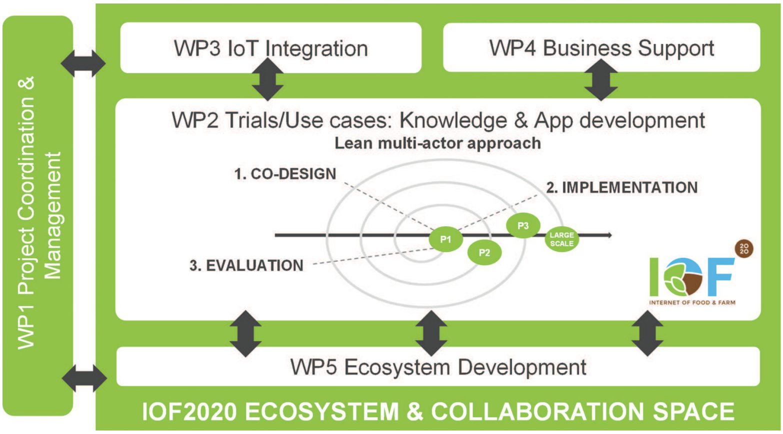


Figure 8.10 IoF2020 Project approach and structure.

(MVPs) in short iterations and the *multi-actor approach* that stresses the active involvement of various stakeholders. The use cases will actively be supported by three other work packages (WPs). WP3 facilitates sharing, reuse and finally integration of IoT components as described in the previous section. WP4 provides business support in terms of monitoring KPIs, business models, market studies and governance aspects (incl. security, data ownership, privacy, liability and ethical issues). WP5 facilitates the development and expansion of the various ecosystems on use case and project level and beyond amongst others by communication, dissemination, organizing workshops and events and by active involvement of European and national communities from the demand- and supply-side of IoT, including industry associations and cooperatives, European Innovation Partnerships, Technology Platforms and ERAnets. A mid-term open call of 6 M€ will be used to further accelerate these developments. This approach establishes a large IoF2020 ecosystem and collaboration space that is expected to sustain after the project.

8.3.5 Conclusion and Outlook

IoF2020 aims to boost the uptake of IoT in European Food and Farming. This will be realized through a balanced set of multi-actor trials and use cases in several subsectors. The use cases are developed in a scalable manner through an open technical architecture and infrastructure with components that can be shared and reused by stakeholders outside the project. This development is leveraged by activities that build-up and extend the total ecosystem, defining attractive and successful business models and solving governance issues. In this way IoF2020 will pave the way for data-driven farming, autonomous operations, virtual food chains and personalized nutrition for European citizens.

8.4 MONICA – Management of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal Applications

The Large-Scale Pilot MONICA demonstrates how cities can use the Internet of Things to deal with sound, noise and security challenges at big, cultural, open-air events. A range of applications will be demonstrated in six major European cities involving more than 100,000 users in total. The project brings together 29 partners from 9 European countries with the objectives to provide

Figure 8.11 An example of the type of open air events that will be addressed by MONICA: here the Kappa Futur Festival in Turin, Italy. MONICA will try to improve the sound experience on events and at the same time reduce the noise for the neighbours. It will also improve responsiveness to security challenges[1].

a very large-scale demonstration of multiple existing and new Internet of Things technologies for Smarter Living.

Imagine sound zones at outdoor concerts in the city where the sound experience is enhanced for those who enjoy the music and the noise mitigated for those who don't. Visualise intelligent cameras deployed at city festivals which, while preserving privacy, estimate crowd size and density in real time, notifying security staff of any unusual crowd behaviour. Or imagine smart wristbands and mobile apps, allowing people to interact with each other and the performers, informing people of the best way out of the venue or guiding them to the nearest exit in case of an emergency.

These are some of the several applications which MONICA will demonstrate at minimum 16 cultural events, taking place all over Europe in Copenhagen, Bonn, Hamburg, Leeds, Lyon and Torino. The broad list of events includes concerts, festivals, city and sport events and involve the use of multiple, wearable, mobile and fixed devices with sensors, such as

[1]Photo courtesy of Simone Arena SIMPOL-lab.

Table 8.1 Overview of Pilot Cities and Events

	City	Event	Avg. Number of visitors per year
	Copenhagen (DK)	• Friday Rock at Tivoli	48.000
	Torino (IT)	• KappaFutur Festival • The Movida	18.000 80.000
	Hamburg (DE)	• Hamburger DOM • Port Anniversary	1.500.000 1.000.000
	Lyon (FR)	• Nuits Sonores • La Fête des Lumières	100.000 3.000.000
	Bonn (DE)	• Rhein in Flammen • Pützchens Markt	300.000 1.350.000
	Leeds (UK)	• Cricket & Rugby matches at Headingley Stadium)	48.000

wristbands, smart glasses, video cameras, loudspeakers, drones and mobile phones. The full list of pilot events is shown in Table 8.1.

8.4.1 Introduction

The deployment of Internet of Things has also a major impact on society specifically in urban environments, where it helps to solve major societal challenges. The rapidly growing number of Smart City platforms enables cities to assemble all their digital applications on uniform communication networks spanning entire cities delivering diverse applications such as health, energy and resource efficiency, and traffic management that help the city to become more environmentally sustainable and citizens to have a better life. In technology areas, standard IoT middleware, architecture and technology enablers have mitigated the complexity of communication and integration and paved the way for a wealth of innovative distributed applications in many vital areas of our society. However, most of the IoT and Smart City platforms are still insufficiently developed to handle really large scale deployment. Health and smart living may potentially involve thousands of users, but they are relatively scarcely distributed, even within a city, and the communication load is limited.

In response, the MONICA platform will demonstrate a resilient IoT platform that addresses major issues of large scale deployments: Scaling, costs of sensors, and intelligence. On this background, the MONICA project is uniquely innovative since it will demonstrate an extremely large uptake of a multitude of IoT applications (10,000+ simultaneous and more than 100,000 different users) using low-costs wearables and apps running on existing wearable platforms such as smart watches and smart phones in combination with wearable sensors. Moreover, the platform will demonstrate heterogeneous interfaces for both expensive, professional infrastructure components and affordable, wearable, and widely used consumer devices. Finally, the demonstration will show closed feedback loops to actuating networks and human interaction and intervention based on situational awareness and decision support.

8.4.2 The MONICA Ecosystems

The MONICA IoT Platform will be demonstrated in the scope of three ecosystems:

8.4.2.1 The Security Ecosystem

The MONICA Security Ecosystem will demonstrate how a multitude of innovative applications for managing public security and safety can be seamlessly integrated with IoT sensors and actuators and used in large scale. The core security and safety challenges at large events, such as those proposed in MONICA, are the handling and mitigation of unforeseen incidents and accidents: personal violence, panic scenes, severe illness of individuals in the middle of a crowd, infrastructure catastrophes such as fire or structural collapses. The aim of any security platform is to ensure the monitoring, recording, identification, analysis of any part of the monitored environment, and measures capable of predicting and, whenever possible, mitigate the danger of potential or imminent events. The modelling of incidents and accidents is therefore necessary in order to be able to deal with episodes while or before they unfold. The Security Ecosystem will consist of a series of large and small applications that, in combination, can be used to monitor and manage the security situation before, during and after an event. The main objectives of the applications are to demonstrate how the IoT platform will seamlessly support open and closed loop solutions that address real-life safety challenges. The traditional security tools used at an event are normally a variety of perimeter security as e.g. fences, supported by CCTV cameras, few entrances with guards and guards working around the area. MONICA will implement additional security and safety measures, e.g. by combining information on the fly for real-time operation and to support the work of security staff. MONICA hence will not change the already existing security concepts of events, rather it will complement extra valuable real-time information supporting the early detection of potentially critical situations.

8.4.2.2 The Acoustics Ecosystem

The MONICA Acoustic Ecosystem will demonstrate how a multitude of innovative applications for managing open air music performances in the public space can be seamlessly integrated with sensors and actuators using the MONICA platform. It will consist of a series of large and small applications that, in combination, can be used to monitor and manage the sound before, during and after a performance. The main objectives of the applications are to demonstrate how the IoT platform will seamlessly support open and closed loop solutions that address real-life environmental challenges e.g. noise in public spaces. E.g. at inner city open air concerts, sound fields will be optimised with respect for both the performers and the concert audience in terms of loudness, directionality and quality. The sound zone system and actuation layer of the MONICA platform allows for dynamic adjustment of the active sound field control loudspeakers, thus, improving the sound quality of visitors while at the same time reducing the noise for neighbours. Health monitoring of sound level exposure can be offered to concerned concertgoers. A cheap, wearable sound level meter in bracelets can be connected to a Smartphone app and continuously measure the cumulative sound dose. The user can thus seek less loud sections of the concert arena.

8.4.2.3 The Innovation Ecosystem

Communication to customers, crowds and citizens is improved by the use of mobile apps and IoT wristbands with value-adding features, enabling people to interact with and locate each other, informing visitors of the best place to park, the best way out or the bars with the shortest queue, and guiding participants to the nearest exit in case of an emergency. General data such as on sound levels are made accessible as open data on the hosting city's websites for citizen engagement and innovation. Applications for user involvement with artists at concerts or among citizens based on different kinds of wearables will be tested. Open APIs will be provided to foster new businesses and start-up solutions based on the MONICA IoT Platform.

8.4.3 User-Driven Pilots

The MONICA platform and its components will be demonstrated in six different pilot cities in different five Member States across Europe and as close as possible to real-life operational conditions under typical load and constraints associated with organising big events. From the pilots, the project will evaluate both qualitative and quantitative success measures towards established KPI's related to stakeholder satisfaction and the improved efficiency in handling of large scale events. In this framework, the following specific activities will take place in the selected pilot sites:

- Integration, deployment and operation of commercially available fixed and mobile devices and development of new wearable devices in the MONICA IoT and relevant Smart City infrastructures.
- Integration, deployment and operation of commercially available fixed and mobile actuating devices and the relevant software applications mentioned above.
- Development and deployment of fully automated closed-loop systems which uses sensing inputs from the IoT network layers to assist humans in monitoring, situational awareness and decision making and provide the resulting control regimes for the actuating IoT infrastructure.
- Validation of pre-defined impact Key Performance Indicators (KPIs) related to each pilot site along with the methodology and the relevant assessment procedures in order to obtain and disseminate qualitative and quantitative date for replication.
- Demonstration of the generic applicability and interoperability of experimental testbeds and open platforms in validation of IoT technologies and identification of where standards are missing and pre-normative activities are needed.
- Development and validation of new markets and business models aiming at involving all actors in the innovation value chain as well as assessing the impact on Europe's Cultural and Creative Industries.
- Active involvement of all actors in the validation and dissemination in order to establish the best possible foundation for creating maximum impact and replication potential from the demonstrations.

In addition to the planned demonstrations, the MONICA deployments addresses – in a smaller scale – the solutions to more generic Smart City challenges i.e. the deployment of a common ICT infrastructure and components in city areas with very diverse needs and context, to deliver services with different business and technical configurations. The specification for the

Figure 8.12 Hamburg DOM is Northern Germany's biggest goose fair. It takes place three times a year in spring, summer and winter and offers its attractions to 7–10 million visitors during the 91 DOM days[2].

MONICA pilots will be extracted from comprehensive use cases and concrete business cases defined by demand-side stakeholders and users. Demand-side representatives in the requirements process will be drawn from the fields of concert organisers, artistic performers, spectators, public authorities, citizens, civic engagement groups, and other relevant groups found inside and outside the consortium. This methodology allows for maximum stakeholder input captured in the analysis of the use cases, the business ecosystem, the value chain interactions and the general societal and environmental realm.

The implementation and deployment of the pilot sides will be based in a mix of commercially available components and solutions, open architectures and design approaches from previous the portfolio of technologies and tools so far developed and demonstrated in reduced and controlled environments as well as targeted research and development of specific prototype solutions where needed. Pilot work plans will include feedback mechanisms to allow adaptation and optimisation of the technological and business approach to the particular use case.

[2]Photo courtesy of Hamburg.de

8.4.4 The MONICA Technical Concept

The MONICA platform features a cloud based on advanced, open IoT technologies dynamically integrating fixed and nomadic devices and truly mobile wearables in the physical world with automated closed-loop actuating functions. The platform will also integrate humans in the loop where appropriate, by providing situational awareness and dynamic decision support tools. A strong toolbox for security and trust management will complement the platform.

The platform will be able to support multiple IoT applications in a wide usage context focusing on the two most important challenges for organisers of large scale concerts and cultural events in large cities: Unwanted noise in the surroundings and security of the audience.

8.4.4.1 The MONICA architecture

The MONICA platform is built on several IoT physical world network infrastructures and a closed loop control system for each application. The components are connected via dedicated communication network and data repositories. The entire solution is embedded in a MONICA Private Cloud structure as visualised in Figure 8.13.

8.4.4.2 The MONICA IoT Infrastructure

The MONICA IoT Infrastructure, depicted in Figure 8.14, must be capable of handling three different types of IoT devices: i) wearable devices, ii) nomadic devices and iii) fixed sensors and fixed Cyber Physical Systems.

Wearable devices include wristbands, glasses and mobile phones. Wristbands are intended to be worn by the spectators and staff while glasses are intended mainly for the security staff. Wristbands have connectivity based on either Ultra-Wideband (UWB) or narrow-band radio (868/900 MHz) technologies. Smart glasses instead will be used, based on the Android OS and equipped with front-facing camera, inertial sensors, light sensor, GPS and pressure sensor. The glasses have real see-through displays with a WVGA resolution and have Wi-Fi b/g/n and BT4.0 connectivity. Nomadic devices are mobile devices confined to the event area, such as hand held sound dosimeters and other sensors (e.g. sound meter, temperature sensor, wind sensor, camera, etc.) mounted on controllable airships. Fixed sensors and Cyber Physical Systems comprise devices mounted on fixed structures in and around the event area, e.g. sound pressure gauges and dosimeters, microphones, cameras, anemometers, etc.

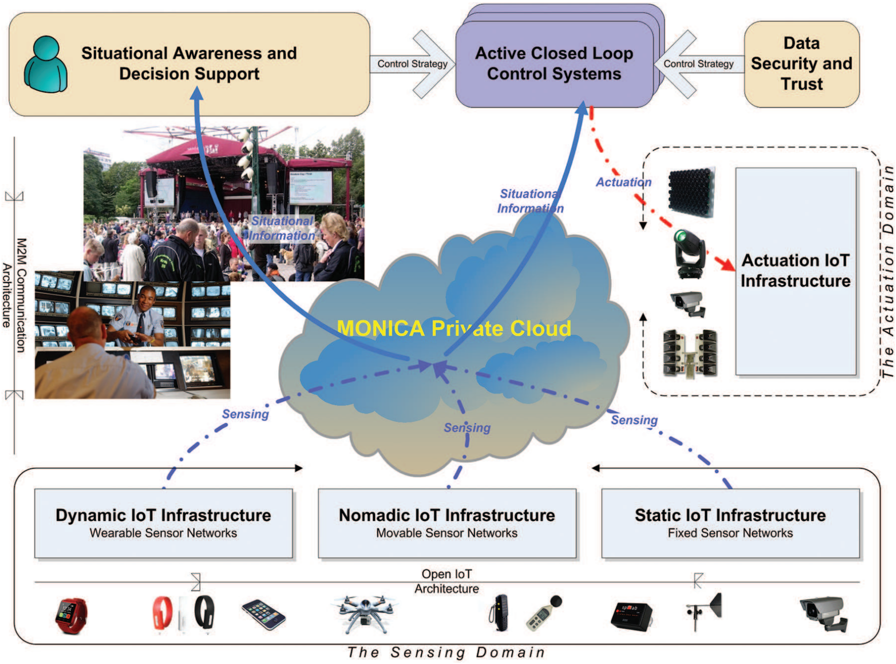


Figure 8.13 The overall MONICA concept.

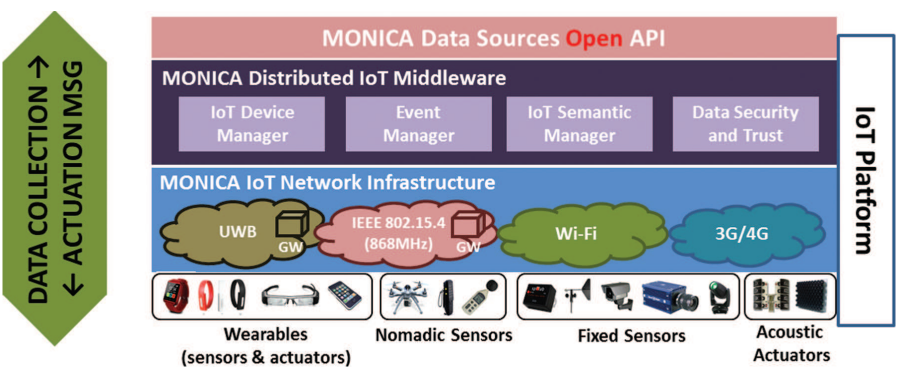


Figure 8.14 MONICA IoT Architecture.

In order to manage the heterogeneity of a large amount of the above-mentioned devices, a proper IoT architecture will be defined following the AIOTI High-level Architecture (HLA) and the AIOTI Domain Model proposed by the AIOTI WG03 – IoT Standardisation. The MONICA Distributed

IoT Middleware will implement the IoT infrastructure using existing IoT gateways and services, e.g. LinkSmart®, FI-WARE, SCRAL, and oneM2M. De-facto standards such as MQTT for publish/subscribe and SAREF (Smart Appliance Reference Ontology, ETSI TS 103 264 standard) and the W3C Semantic Sensor Network Ontology for semantic modelling will be applied.

8.4.5 Conclusion and Outlook

The MONICA project will carry out unique demonstrations of large scale take up of IoT deployments at highly relevant inner city cultural open-air events. It will pave the way for innovative business opportunities for technology and software providers in the field of IoT. Ultimately, the project aims to improve the quality of life in our cities for all citizens.

8.5 SynchroniCity: Delivering a Digital Single Market for IoT-enabled Urban Services in Europe and Beyond

Smart cities hold the potential to be a key driver and catalyst in creating a large scale global IoT market of services and hardware. However, the emerging smart city market faces specific challenges that act as barriers to growth, impeding rapid innovation and inhibiting widespread market adoption.

SynchroniCity is an ambitious initiative to deliver a **digital single market** for Europe and beyond **for IoT-enabled urban services** by piloting its foundations at scale in reference zones across eight European cities and involving other cities globally. It addresses how to incentivize and build trust for companies and citizens to actively participate and find common co-created IoT solutions for cities that meet citizen needs, and to create an environment of evidence-based solutions that can easily be replicated in other regions. These reference zones are based on cities at the forefront of smart city development covering different geographies, cultures and sizes and include Antwerp (BE), Carouge (CH), Eindhoven (NL), Helsinki (FI), Manchester (UK), Milano (IT), Porto (PT) and Santander (ES). Globally, SynchroniCity adds committed replicating reference zones in Mexico, Korea, USA and Brazil.

8.5.1 Introduction

Digital technologies offer an opportunity to profoundly change how our existing society works. They can enable a transformation of different industry

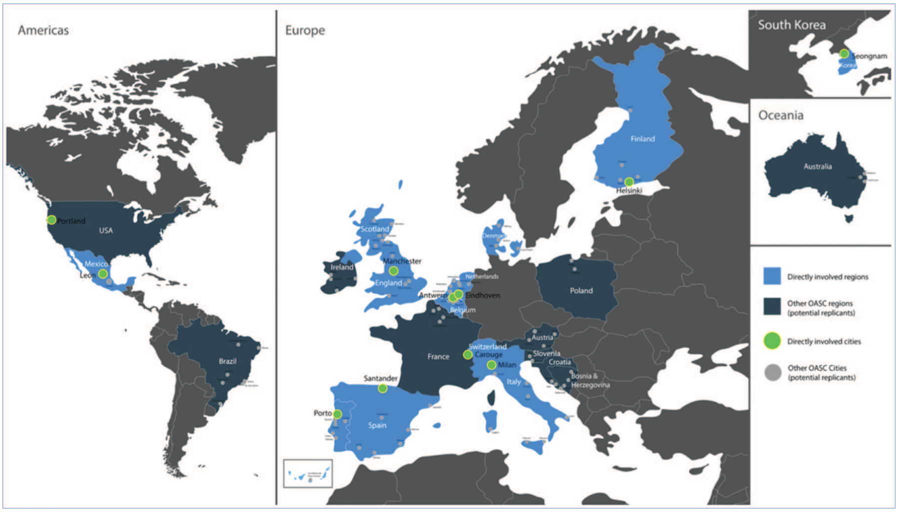


Figure 8.15 SynchroniCity cities and regions.

sectors improving existing business activities, processes, and competencies within organizations and across their boundaries.

Data infrastructures and the Internet of Things (IoT) form a critical part of the digital transformation of cities and communities by creating adequate awareness of real-world processes in order to drive more efficient, partially autonomous, decision making, while still maintaining a high level of data protection, inclusivity and general support for local priorities such as economic development and cultural heritage.

In terms of data infrastructures, cities have been at the forefront of embracing the open data movement. The release of data sets to the public has increased transparency and provided early innovation potential for third party stakeholders. Services such as Citymapper[3] show how open data can add great benefits to the journey experiences of citizens.

Many cities have invested in the setup of open data portals and proactively encourage stakeholders across public departments and the private sector to contribute data sets. At the same time, cities are trying to engage entrepreneurs and communities to innovate around these data stores. Early results are promising, but static or sporadically changing data sets have their limitations.

[3]https://citymapper.com/

Figure 8.16 Street light in Santander.

IoT infrastructures are increasingly becoming an important element in providing the underpinning digital layer of smart city services. They augment the open data sets with rich real-time information about public infrastructure conditions and city processes that can be exploited for a more responsive delivery of public services. Examples range from an improved mobility experience through adaptive traffic management and multi-modal transportation to resource savings achieved by smart street light control, waste collection and irrigation management.

Various demonstrations of such systems are emerging globally showing the benefits of data-driven services based on IoT and data infrastructures. However, many of these systems currently operate in silos both in terms of the technology employed and the operating environments of the city. Interoperability issues and lack of economies of scale make many potential business cases still hard to justify and result in a lack of confidence in the market.

SynchroniCity aims to overcome the existing barriers in the market by fostering the emergence of a digital single market for smart city services. It brings eight European cities together to work on a common blueprint for IoT and data infrastructures with standardized interfaces and information models, creating an environment that allows vendors and solution providers to more openly compete.

Our vision is to move from disparate data stores and city platforms to vibrant marketplaces for urban data and services providing adequate incentives for a variety of stakeholders to participate. For providers of IoT infrastructure and other urban data sources, this should provide a trusted environment to generate reliable revenue flows. For application and service developers, it should allow frictionless access to reliable and trusted urban data streams to be used as assets underpinning the innovation no matter what city is involved. We call this aspect “avoiding city lock-in”. Cities and infrastructure providers can benefit from an aligned environment with standardised interfaces to access a diverse pool of vendor solutions able to compete fairly on price and performance. We call this aspect “avoiding vendor lock-in”. Together, they form the robust underpinnings of a global market for IoT-enabled urban services.

8.5.2 Technical and Non-Technical Barriers of Creating a Smart City Eco-System

SynchroniCity addresses a wide range of technological and non-technological barriers that need to be overcome to enable necessary economies of scale and market confidence to emerge.

The key technological barriers include:

- Lack of standardized multi-vendor ecosystem, leading to fear of vendor lock-in for many cities;
- Lack of common service provisioning environments across cities, leading to fear of city lock-in for service developers as they need to “redevelop” major parts of their apps and renegotiate access to different data sources for every city;
- Close coupling of IoT infrastructure and applications, leading to IoT solution silos and limited infrastructure reuse;
- Lack of tools, license models and platforms to facilitate the incentivized sharing of urban IoT data and other relevant data sets;
- Lack of harmonized business practice and legal frameworks across cities – making IoT infrastructure roll out and launch of new services tedious across different geographies;

- Lack of understanding of privacy and personal data protection implications – making it difficult to fully leverage data of citizens collected in public spaces in responsible way; and
- Lack of confidence in adopting emerging technologies due to increasing technology fluidity – rapid change and emergence of new standards make it hard for cities to understand where sustainable investments can be made.

Besides technological challenges, cities offer unique constraints and non-technological barriers, which hamper the adoption of IoT technologies. They include:

- Economical costs and budget constraints make it difficult to for cities to make major investments in newly emerging technologies;
- Inflexible public tender processes and procurement models complicate experimental exploration with new technology solutions;
- Frequent political changes and reliance on election cycles leads often to reprioritisation and lack of continuity to focus on longer term innovation programmes;
- Lack of a holistic smart city strategy leads to investments in fragmented systems for different verticals, making it difficult to capitalise across these and gain cost savings; and
- Lack of involvement of citizens and support from these can lead to smart city solutions not addressing real citizen needs and fuel the mistrust of citizen in adopting new technology solutions.

8.5.3 SynchroniCity Technical Approach

Overcoming the barriers identified above requires a common approach across the different reference zones. In the following we introduce the key foundations for our vision of the SynchroniCity digital single market.

Technical barriers 1–3 and in part 7 demand a common reference architecture for smart city platforms. A standardised reference architecture, which is widely adopted among many cities with clearly defined components and interfaces is fundamental to overcome vendor lock-in. It will boost market confidence and lay down the foundations for the required economies of scale.

Key elements in this reference architecture are common north- and south-bound interfaces. Technical barrier 4 demands new market place enablers that encourage sharing of urban IoT data and other relevant data sets among

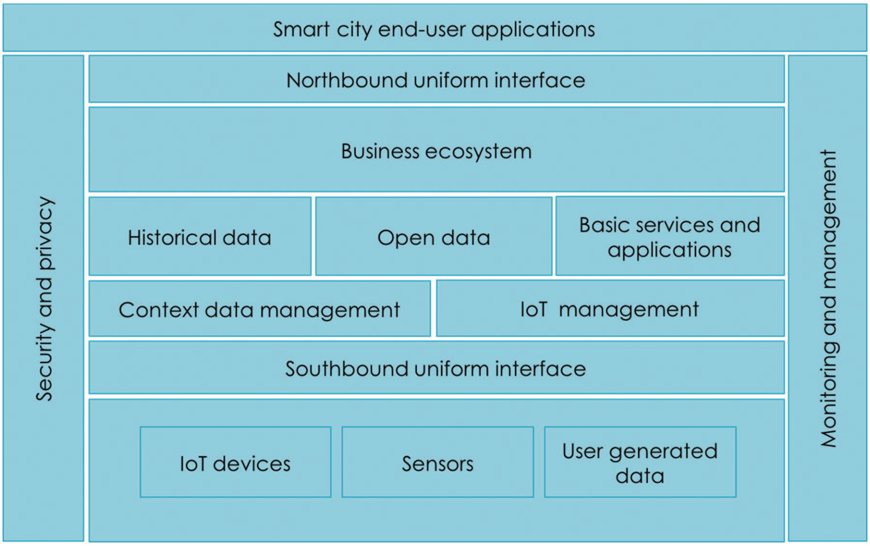


Figure 8.17 High level architectural view of the SynchroniCity single digital market.

different stakeholders. Lastly, barriers 5–6 relate to finding agreement on common principles of governance of a digital single market.

Figure 8.17 shows an overview of the proposed components of the SynchroniCity single market place including common north- and southbound interfaces. A further important feature is the market place enablers that underpin a thriving business eco-system around IoT data streams, actuation capabilities and other urban data sources. In the following we briefly describe each of these.

A common reference architecture for smart city platforms. A standardized reference architecture, which is widely adopted among cities with clearly defined components and interfaces, is fundamental to overcome vendor lock-in. It will boost market confidence and lay down the foundations for the required economies of scale.

Common northbound interfaces. Developers require a common, homogeneous and IoT independent way to access data from the devices infrastructure, but also from any other subsystem in the city that can provide valuable information to develop smart services and applications. More specifically, this includes 1) a common standard API for context information management; 2) a common set of information models enabling actual interoperability of applications; and 3) a set of common standards data publication platforms have to comply with, enabling the harvesting of data coming from multiple federated platforms as well as the publication of real-time open data.

Common southbound interfaces. For IoT device vendors and manufacturers it should become easier to offer suitable device stacks for integrating heterogeneous IoT components into a common environment, together with a market place for compliant IoT products and solutions.

Market place enablers. These should encourage sharing of urban IoT data and other relevant data sets among different stakeholders. By providing a market place as a one-stop-shop, it will become much easier for data consumers to discover and access urban data sources. The availability of a trusted market place with monetization mechanisms will allow third parties to generate easier revenue streams from their urban data sources. This will encourage more businesses to share currently closed data sources or incentivize deployments of new IoT infrastructure as secondary revenue streams can be generated, making more business cases viable. Data consumers may not require lengthy negotiations of license terms as data license terms can be negotiated from pre-configured options of the provider on the fly.

8.5.4 SynchroniCity Applications

Based on the shared architecture, SynchroniCity will deliver IoT-enabled urban services in the eight reference zone cities. The services will be developed and delivered in an ambitious two-stage approach.

First phase consists of three *initial applications*, based on the highest priorities among the members of the global Open & Agile Smart Cities initiative, a network of more than 100 cities worldwide which includes the SynchroniCity reference zones:

- Community Policy Suite
- Context-adaptive traffic management
- Multi-modal transportation

These applications are fairly standard services nowadays. However, there are still significant gaps when it comes to actually delivering them at scale, based on digital single market principles. Not all the SynchroniCity cities are involved in the deployment of all the initial applications.

The following phase is called "enrichment of the eco-system", and it adds another wave of *new applications* to the SynchroniCity portfolio, based on an open call where new companies and cities may propose applications and services built on top of the SynchroniCity architectural principles.

Figure 8.18 Interactive light art in Eindhoven.

A total of 3 million Euros has been allocated for the new applications, and the call for participation will launch in the spring of 2018.

Taken together, the applications developed and deployed at large scale in SynchroniCity will form a substantial contribution to a global market for IoT-enabled urban services.

8.5.5 Impact Creation

SynchroniCity consists of eight core reference zones in as many cities, but the ambition is to go well beyond this starting point: beyond the reference zone to the entire city, beyond a single silo to span multiple domains, and to go beyond Europe.

To reach this goal, the project was founded on a strong partnership basis with existing initiatives and communities, and has defined a set of ambitious KPIs.

At the core of SynchroniCity is the Open & Agile Smart Cities initiative (OASC)[4] which is a global network of national networks of more than

[4]www.oascities.org

100 cities in 23 countries that are working together to contribute to the establishment of a simple set of mechanisms for technical interoperability and comparability based on the needs of cities, i.e. the demand-side in the market. By adding global partners in Mexico, USA, Korea and Brazil, SynchroniCity spans a large diversity which is a characteristic of a global market. Potentially, the entire OASC network can easily adapt and deploy the SynchroniCity applications. Figure 8.15 shows the European reference zones, the global partners and the OASC cities.

A key focus of SynchroniCity is to contribute to the development of common specifications and ultimately standards. As shown in Figure 8.19 below, SynchroniCity takes input not only from OASC and the cities directly involved in the project, but also from other large initiatives, including prominently the FIWARE[5] initiative and the European Innovation Partnership on Smart Cities and Communities (EIP-SCC)[6]. Through targeted activities and deliverables as well as participation directly in the specification and standards development, SynchroniCity is contributing directly to a number of streams, including the ETSI Industry Specification Group on Context Information Management (ETSI ISG CIM)[7], the ITU-T Focus Group on Data Processing and Management for Smart Cities and Communities (FG-DPM)[8], and ISO/TC 268 on Sustainable cities and communities[9]. The project actively supports and contributes to the UN Sustainable Development Goals[10].

By having the open call where actors outside of the SynchroniCity project consortium are invited to enrich the eco-system, SynchroniCity actively seeks to facilitate support and impact beyond the closed group of initial partners.

8.5.6 Conclusions and Outlook

SynchroniCity has a clear ambition to deliver local value in cities and communities based on the global dynamics of digital connectivity, innovation power and capital. So far, efforts to create a global multi-sided market based on demand-side needs have not been successful. With the approach described above, the partners in the SynchroniCity consortium propose an approach

[5] www.fiware.org
[6] www.eu-smartcities.eu
[7] https://portal.etsi.org/tb.aspx?tbid=854&SubTB=854
[8] http://www.itu.int/en/ITU-T/focusgroups/dpm
[9] https://www.iso.org/committee/656906.html
[10] https://sustainabledevelopment.un.org/?menu=1300

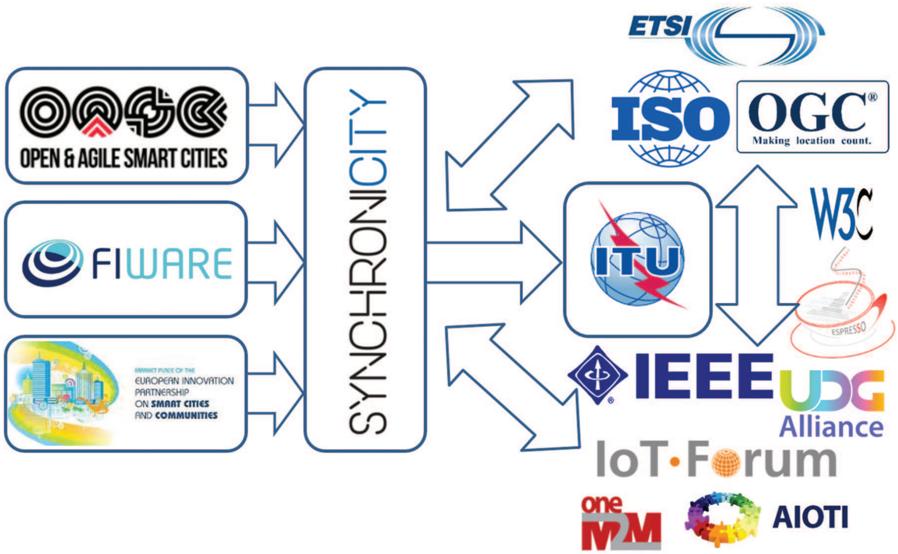


Figure 8.19 The SynchroniCity contribution to standards developing organisations.

which leverages interests from both sides of the market, with a clear focus on having humans in the centre. Together with the rest of the IoT Large Scale Pilot projects, SynchroniCity will hopefully bring Europe and the world a step closer to a well-functioning market, based on human needs and life between the systems.

8.6 AUTOPILOT – Automated Driving Progressed by Internet of Things

"AUTOmated driving Progressed by Internet Of Things" (AUTOPILOT) is a three-year project that started in January 2017, receiving funding from the European Union's Horizon 2020 research and innovation programme. The AUTOPILOT consortium, consisting of 45 partners, represents all relevant areas of the Internet of Things (IoT) eco-system. Its overall objective to enable safer highly automated driving through smart and connected objects – the IoT[11].

[11] Fischer, F. & Corazza, F. (2017).

8.6.1 Project Overview

During the last decade, numerous IoT technologies have been developed by the research community, including IoT software engineering tools and techniques, schemes for safeguarding security/privacy as well as infrastructures. Built upon these recently finished or ongoing research and innovation activities, AUTOPILOT focuses on utilising the IoT potential for automated driving and on making data from autonomous cars available to the IoT. In particular, AUTOPILOT aims to bring together relevant knowledge and technology from automotive and IoT value chains in order to develop IoT-architectures and platforms to explore the growing market for mobility services. IoT-enabled autonomous cars are tested, in real conditions, at six large-scale sites, whose test results will allow multi-criteria evaluations (technical, user, business, legal) of the IoT impact on pushing the level of autonomous driving.

8.6.1.1 Objective

Connectivity and the ability to collect data from thousands of objects surrounding vehicles are key enablers for highly automated driving. The IoT provides the mechanisms and tools to create virtual objects in the Cloud from real connected objects, thereby allowing these objects to become more automated in the not-so-distant future.

Overall, AUTOPILOT pursues five main objectives. First, it seeks to enhance the vehicle's understanding of its environment, utilising IoT sensors. Second, the project sets out to foster innovation in automotive IoT and mobility services. Third, it wants to use and evaluate advanced vehicle-to-everything connectivity technologies. Fourth, AUTOPILOT is designed to involve users, public services and businesses to assess the IoT's socio-economic benefits. Last, the project aims to contribute to the standardisation of IoT eco-systems worldwide.

More concretely, AUTOPILOT proceeds in four steps (see Figure 8.20). On large-scale test sites, data is collected in an IoT eco-system, defined as "objects in the physical world, which are capable of being identified and integrated into communication networks". Next, this data is collated and

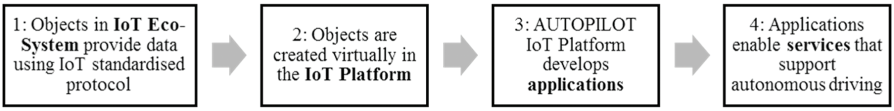


Figure 8.20 Project flow.

analysed in an IoT Platform, defined as “interconnecting things based on existing and evolving interoperable ICTs”, which is specifically dedicated to Automated Driving (see Section 8.6.2.1). The IoT Platform is then used for four use cases to test applications on Automated Driving (see Section 8.6.2.2). Ultimately, AUTOPILOT suggests some services, which can serve as business models for translating IoT Applications (see Section 8.6.2.3) into tangible offers for end users of automated driving.

8.6.1.2 Partners

The AUTOPILOT consortium brings together 45 partners from multiple countries and diverse backgrounds. The consortium is a balanced mix of organisations working in IoT as well as in Automation. This cooperation is an asset, because both industries have a very different approach to data sharing and vehicle control. IoT devices are by definition shared and open while automotive electronics are closed and safety-critical. The partner constellation in AUTOPILOT helps to overcome this problem and thus fosters implementation of IoT solutions in future vehicle architecture. The idea behind the consortium is to combine a wide range of knowledge areas to foster the project’s effectiveness in attaining its objectives. Lastly, the AUTOPILOT consortium provides an avenue for authorities into the project. City authorities of the project sites are as much part of the consortium as are road operators.

Overall, the AUTOPILOT consortium can be characterised in four clusters: (1) those developing AD vehicles, (2) those developing IoT and networks, (3) those collecting data to evaluate the systems and their potential impacts, and, (4) those potentially developing innovative services based on the results. This comprehensive mix of partners is a key to the project.

8.6.2 Project Approach

AUTOPILOT follows a two-track approach, composed of both pragmatic and conceptual platform development. On the one hand, the pragmatic architecture serves not only as starting point for the development of the conceptual and unified platform but also as starting point for the use cases at the different Pilot Sites. On the other hand, the conceptual architecture is deployed very early and can be used by any new development. The conceptual architecture is to be used as the reference for discussion and collaboration with other Large Scale Pilots. To swiftly achieve tangible results, AUTOPILOT utilises pragmatically existing systems or other available installations.

In addition, AUTOPILOT adopts an iterative approach for innovation activities, known as Iterative and Incremental Development (IDD). The main rationale for IID in the design phase is to allow the project to better adapt to changing contexts, requirements, technological developments and boundary conditions. Therefore, the requirements are not frozen at the early stage of the project but will be reviewed based on preliminary evaluation results.

A maximum of three cycles is foreseen, whereas the need for applying all cycles is likely to be different for the partners and Pilot Sites, according to their level of maturity in IoT and automated driving at the start of the project. The multiple cycle approach offers all partners the necessary level of flexibility concerning their participation in the project as well as harmonising their contributions to the project.

The specific motivation for this approach in AUTOPILOT is threefold: First, there is a technical justification. One needs to merge the need to integrate many different components, with the need to start from existing solutions and adapt to users' early feedbacks. Second, there is an organisational justification, as Pilot Sites will learn from each other between cycles. Third, there is a business justification, as initial solutions to show on the demand side can pointedly visualise the demand side to IoT solutions for automated road transport.

8.6.2.1 AUTOPILOT's IOT Platform

AUTOPILOT's IoT Platform is held responsible on six parameters of design.

- Standard-Based: Legacy or proprietary IoT systems can be integrated into a common system;
- Abstraction: Abstraction-based information model following established High-Level IoT Architecture;
- Federation: Private and public IoT systems can co-exist and collaborate on-demand;
- Semantic: Based on formal semantics to achieve automated processing of large variety of information;
- Functional Distribution: Architecture enabling functional elements to be allocated into systems;
- Security: Provision of security functions and implementation of the "Privacy-by-Design" principles.

Today's IoT installations are mainly *Intranet-of-Things* meaning closed systems developed for a single commercial purpose and all following the same design principles. But the vision of AUTOPILOT is calling for an open IoT system, in which many participants are publishing and consuming IoT data and services. This is alike the Internet in which many participants can operate their own Web site. As shown with traditional Web-based systems, there is a need for aggregation and federation services, supporting developer and end-user with high-quality services (e.g. Google search, hotel booking engines, news aggregation services).

Those services are especially needed in the IoT for autonomous driving areas. Automated driving service operators will prefer to use a single service, delivering high quality and reliable information, rather than having to interface with thousands of information sources and service providers. This is called the IoT Federation, where autonomous systems agreed to collaborate by exchanging data and providing services to each other. The AUTOPILOT conceptual architecture provides such federation mechanism following the federation design principle. For example, for data access the FIWARE IoT Broker provides a large-scale federation infrastructure. Federation enables a finer grain control over IoT information compared to centralised IoT clouds. Federation also enables privacy-by-design thanks to clear policies and control points for information access.

Today's autonomous driving applications are relying on autonomous vehicle systems in which the needed information is gathered, processed and analysed on the vehicles themselves. As a consequence, the vehicle platform can base its driving and manoeuvring decisions solely on local information (Autonomous Car Zone). In the past year, newer approaches for cooperative driving have emerged, where driving functions take information gathered from other devices into account, e.g. using Car2Car or Car2Infra approaches (Cooperation Zone). With the emergence of the IoT, autonomous driving services can utilise IoT devices from the surrounding as well as services from the Cloud

8.6.2.2 Project Sites and Applications

AUTOPILOT employs large numbers of vehicles under normal traffic conditions, for which trials are being conducted at six large-scale Pilot Sites (Table 8.2).

- The Finnish Pilot Site, located in Tampere provides different outdoor conditions, such as slippery intersection in winter time, low visibility for environment perception sensors due to fog.
- The French Pilot Site is located in downtown Versailles, close to the castle. Its goal is to provide mobility services for tourists, based on a small fleet of automated vehicles and dedicated to a car-sharing.

- The Italian Pilot Site, is a testing infrastructure encompassing the Florence-Livorno highway together with road access to the settlement around the Livorno seaport.
- The Korean Pilot Site in Daejeon focuses on road situation information at an intersection, which is challenging for automated vehicles because of the large number of obstacles to be encountered there.
- The Dutch Pilot consists of three different test areas, including the Eindhoven University campus, the automotive campus parking, and a 6 km stretch of the A270 motorway.
- The Spanish Pilot Site is located in Vigo, covering the city's main street. It provides an operational test on cooperative systems between different types of vehicles and for underground parking.

AUTOPILOT deploys four different automated driving use cases: Automated Valet Parking (AVP) is a driverless Automated Driving use case including on-street car drop-off, driving to and from a parking spot, forwards and backwards manoeuvring as well as on-street passenger pick-up. The IoT allows this use case to be a Level 4 scenario, since data and control from different infrastructure sensors is essential. IoT functions include routing (parking availability through sensors), localisation of obstacles (parking cameras) and even control decision making at the IoT Edge.

Table 8.2 AUTOPILOT project sites and applications

Country	City/Region	Valet Parking	Highway Use	Platooning	Urban Driving
	Tampere	✓			✓
	Versailles	✓		✓	✓
	Livorno-Florence		✓		✓
	Daejeon				✓
	Eindhoven-Helmond	✓	✓	✓	✓
	Vigo	✓			✓

Highway Use is a use case focused on Automated Driving on motorways from entrance to exit, on all lanes, incl. overtaking. The driver must deliberately activate the system, but does not have to monitor the system constantly. There are no requests from the system to the driver to take over when the systems in normal operation area (i.e. on the motorway). Depending on the deployment of cooperative systems ad-hoc convoys could also be created if V2V communication is available.

The use case for Platooning is an Automated Driving scenario where fully automated driving or driverless vehicles will join and drive in a platoon, with a leading vehicle in front. The driving mode is very similar to the Highway Pilot, however driving in a platoon requires the vehicle to use advanced V2V communications. Two variants of platooning will be deployed and evaluated in AUTOPILOT, an urban one and a highway one.

The Urban Driving use case is based on the ERTRAC "Fully automated private vehicle" representing the SAE level 5, where "The fully automated vehicle should be able to handle all driving from point A to B, without any input from the passenger."

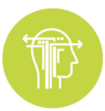
8.6.2.3 Services the intersection of IoT and automation

As stipulated in its acronym, AUTOPILOT seeks to foster the progress of automated driving. For this purpose, it makes use of the innovation of IoT developments in the field. Throughout the project, members of the consortium will work to develop eight specific services that draw on the use case applications of IoT (see Table 8.3). These services fulfil a double function. On the one hand, they make the idea of automated driving progressed through the IoT tangible for end users. On the other hand, they suggest viable business models for stakeholders that will carry on the findings of AUTOPILOT even after it ended.

8.6.3 Project Impact

To provide quantitative and qualitative evidence of the added value of IoT technology for automated driving, all large-scale Pilot tests are evaluated using the established FESTA methodology. The added value is formulated in hypotheses on objectives, ambitions and impact, and is measured in Key Performance Indicators (KPIs) or metrics from several perspectives. Data analyses and (technical) evaluation will be executed simultaneously with piloting to provide immediate feedback on test executing and input for the next iteration of development.

Table 8.3 IoT based automated driving services

	**City chauffeur services for tourists** Adaptation of car-sharing, dedicated for tourist to visit cities and other remarkable locations, being out of the loop to follow a multimedia presentation of the site in the vehicle.
	**Automated driving route optimisation** Monitoring of vehicles and environment to optimise automated driving routes to autonomous driving cars, by redistributing the traffic along alternative paths towards available parking spots.
	**Real time car sharing** Optimisation of vehicle allocation through collection of end user needs and analysis of IoT platform data to suggest car sharing (pick-up/drop-off) possibilities.
	**Driverless car rebalancing** Rebalancing of car sharing vehicles, with automated driving vehicles moving driverless from their last drop-off zone towards another pick-up location, either alone or in a platoon.
	**HD maps for automated driving vehicles** Provision of High-Definition maps data base for Automated Driving vehicles, built on the data collected by all connected vehicles.
	**6th Sense driving** Provision of risk metrics contributing to road assessment programme to create specific metrics and services for road rating dedicated to the autonomous driving capabilities of roads.
	**Dynamic eHorizon** Update of IoT based HD map data service through data from other vehicles' sensors and from other sources in real time, enabling to factor in dynamic changes to the route.
	**Electronic driving license** Generation and storage of secured identity profile to allow dedicated access to any smart city platform.

AUTOPILOT will focus on using standard-based IoT to ensure deploying interoperable and replicable IoT platforms and architectures. It will verify the interoperability and functionality during the development phase. Security and privacy by design will be a key impact of AUTOPILOT. Additionally, AUTOPILOT will deploy and evaluate several business services contributing or using automated driving. In this, the project will have to assess possibly competing elements of user acceptance, such as the perceived usability, ethical aspects and liability.

Overall, AUTOPILOT will pilot the use cases in a real public and private environment, with the consent and strong support of the City councils, some being in the consortium. Services like car sharing, city chauffeur and automated valet parking are expected to increase citizens' quality of life. The Pilot Sites, with their different automated driving use cases and business partners are an instrument to attract new entrepreneurs for creating further business opportunities. AUTOPILOT will promote the IoT as key enabler for automate driving and the related new business models linked with the IoT eco-system.

8.7 CREATE-IoT Cross Fertilisation through Alignment, Synchronisation and Exchanges for IoT

CREATE-IoT is the coordination and support action involving all IoT European Large-Scale Pilots innovation actions projects, articulating altogether the IoT European Large-Scale Pilots Programme that is built around eight activity groups. Through an active participation of these activity groups, IoT Large-Scale Pilot projects are able to contribute to the consolidation and coherence work that is implemented by the CREATE-IoT and U4IOT. This is done by supporting the clustering activities defined by the Programme and addressing issues of common interest such as interoperability approach, standards, security and privacy approaches, business validation and sustainability, methodologies, metrics, etc.

The ultimate goal of the IoT European Large-Scale Pilots Programme and the coordination/collaboration activities is to increase the impact of the activities and development in the IoT Large-Scale Pilots on citizens, public and private spheres, industry, businesses and public services. The activity groups are key enablers for the identification of key performance indicators to measure progress on citizen benefits, economic growth, jobs creation, environment protection, productivity gains, etc. The coordination mechanisms implemented through the activity groups will help to ensure a sound coherence and exchange between the various activities of the IoT Focus Area, and cross fertilisation of the various pilots for technological and validation issues of common interest across the various use cases.

The issues of horizontal nature and topics of common interest, for all IoT Large-Scale Pilot projects, such as privacy, security, user acceptance,

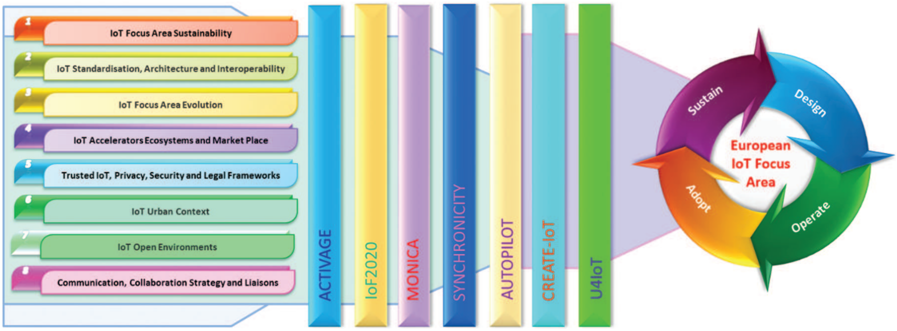


Figure 8.21 IoT European Large-Scale Pilots Programme Activity Groups.

standardisation, creativity, societal and ethical aspects, legal issues and international cooperation, etc., are coordinated by the activity groups (Figure 8.21) and consolidated across the pilots to maximise the output and to prepare the ground for the next stages of deployment including pre-commercial or joint public procurement.

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

The activity groups monitor that appropriate mechanisms are put in place so that pilots' impact can go beyond involved partners by also reaching external communities and stakeholders. Special attention should be given to those pilot projects which intend to launch open calls through cascade funding. Mobilising a wider community beyond the consortium is essential for the development of a secure and sustainable European IoT ecosystem. Beyond sustaining an ecosystem it is instrumental to include contributions to assure that the IoT infrastructures developed and implemented are viable beyond the duration of the Pilots.

The IoT European Large-Scale Pilots Programme coordination body led by the supporting and coordination actions, being CREATE-IoT part of it, will continuously monitor and adapt through the activity groups the common topics, challenges, best practices in order to maximise the expected impact of the IoT Large-Scale Pilots and coordination actions as outlined below:

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

8.7.1 Introduction

CREATE-IoT brings together 19 partners from 9 European countries. The project objectives are to stimulate collaboration between IoT initiatives, foster the take up of IoT in Europe and support the development and growth of IoT ecosystems based on open technologies and platforms. This requires synchronisation and alignment on strategic and operational terms through

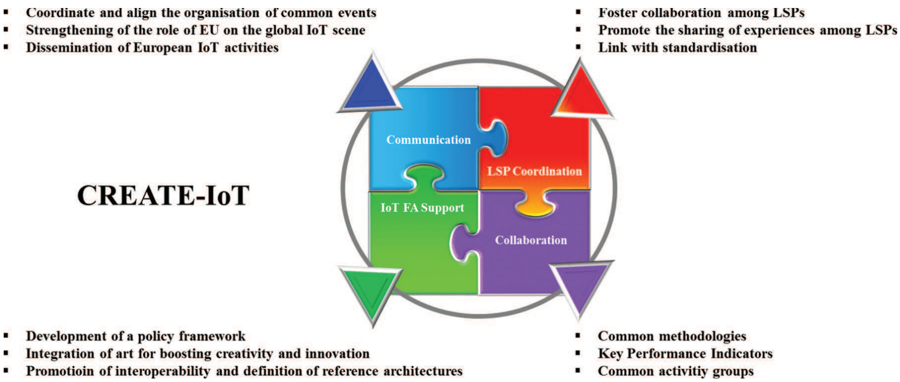


Figure 8.22 CREATE-IoT activities.

frequent, multi-directional exchanges between the various activities under the IoT Focus Areas as depicted in Figure 8.22. It addresses cross fertilisation of the various IoT Large Scale Pilots for technological and validation issues of common interest across the various application domains and use cases. The project fosters the exchange on requirements for legal accompanying measures, development of common methodologies and KPIs for design, testing and validation and for success and impact measurement, federation of pilot activities and transfer to other pilot areas, facilitating the access for IoT entrepreneurs/API developers/makers, SMEs, including combination of ICT and art.

CREATE-IoT takes a holistic approach in facilitating the exchange between the different IoT Large-Scale Pilot projects and providing the appropriate platform and tools that will enable fruitful cross-fertilization between IoT Large-Scale Pilots.

8.7.2 Conceptual Approach

CREATE-IoT aims to provide support to the different activities covered by the IoT Focus Area through the development of a coherent strategy for open exchanges and collaboration between the various actors involved. CREATE-IoT is focusing on promoting and discovering synergies across the different axes of the IoT Focus Area, as shown in Figure 8.23. The horizontal nature of (personal) data protection, security, user acceptance, standardisation, interoperability, creativity, societal and ethical aspects, legal issues and international cooperation are coordinated across the whole IoT ecosystem. Special attention is paid to the Large-Scale Pilots, but also to other initiatives

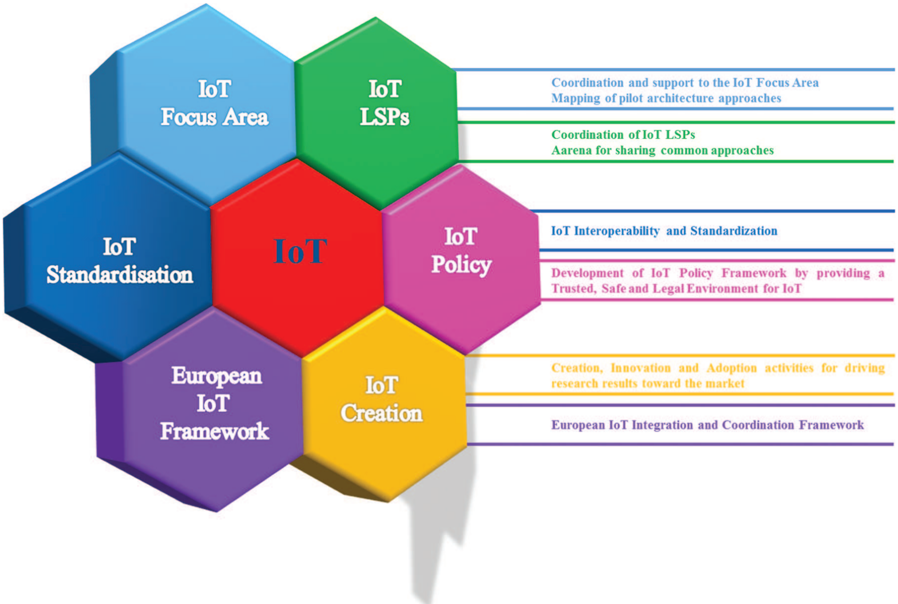


Figure 8.23 CREATE-IoT project axes.

in the IoT Focus Area, and other related initiatives at EU and global level involving different IoT communities, technology and innovation platforms, etc. The project boosts synergies, experience and knowledge sharing towards the creation of an inclusive IoT ecosystem, by defining a set of best practices and business models that will facilitate the replication of results and, thus, improve the overall impact of the parallel on-going activities, in particular the IoT Large-Scale Pilot projects. In summary, CREATE-IoT is working on:

- Ensuring coherent exchanges between the various activities of the Focus Area, and cross fertilisation of the various pilots for technological and validation issues of common interest across the various use cases.
- Supporting and assessing the current IoT Large-Scale Pilot projects, sharing best practices and aligning horizontal issues.
- Developing a more inclusive ecosystem where innovation, art and creativity take active part on it.
- Proposing a framework for the coherent integration of the EU IoT value chain, strengthening the links between different on-going initiatives in the IoT domain.
- Fostering interoperability of existing and future IoT solutions.

- Implementing and developing a policy framework in the IoT domain addressing the current horizontal issues that prevent the from massive deployment of IoT solutions, with a special focus on the trust and legal domains.

The project methodology is based on a clear definition of the current IoT ecosystem. The work provides the overall foundation for common inter-linking and coordination activities: all relevant stakeholders, technologies, reference architectures and business models will be the base over which the project will grow. The support to the IoT Large-Scale Pilot projects, as addressed by the project, fosters the sharing of experiences both from technical and non-technical perspectives. On the technical side, CREATE-IoT is focusing mainly on the federation of experiments and IoT reference architectures, whilst the non-technical side aims at sharing experiences, assessment methodologies and business models. The project exploits the synergies between arts and IoT and position creativity and innovation as a key driver and enabler for the progress of IoT. The methodology resulting from this work is tested in the different LSPs. The project addresses the creation of a framework for an integrated European IoT Value Chain that will grow the links between communities of IoT users and providers, as well as with Member States' initiatives and other related initiatives in the IoT domain.

The development of a Policy Framework will help addressing the multiple existing challenges, especially in the security and privacy domain, which are hindering the wide adoption of IoT solutions. The requirements for a trusted IoT label are under discussion. This label would better position EU IoT solutions in the global markets, being applicable not only to the whole IoT Focus Area, but also to other IoT domains. CREATE-IoT works on supporting industrial consensus building for implementing pre-normative and standardisation, coordinating the activities with Standard Developing Organizations (i.e. ISO, ETSI, CEN/CENELEC, W3C, IETF, ITU, IEEE, OGC, etc.) and other various IoT Global Alliances (AIOTI, IIC, Thread, AllJoyn, Open Connectivity Foundation (OCF), etc.), thus aligning activities at the national, European and global level.

8.7.3 Impact

CREATE-IoT provides the framework for supporting and coordinating the IoT Focus Area, in order to foster the take up of IoT in Europe and enable the emergence of IoT ecosystems supported by open technologies and platforms.

This is done through the coordination of complementary activities structured around IoT Large-Scale Pilots

The project ensures the framework environment and provides tools to ensure consistency and linkages between the pilots, complementing them by addressing ethics and privacy, trust and security, respect for the scarcity and vulnerability of human attention, validation and certification, standards and interoperability, user acceptability and control, liability and sustainability. The project implements a coordination body that ensures an efficient interplay of the various elements of the IoT Focus Area and liaises with relevant initiatives at EU, Member States and international levels.

For today's and tomorrow's IoT products, services, applications, solutions infrastructure and ecosystems, it is crucial that the society, its citizens and other (potential) customers and users have trust in what they use, buy, wish to enjoy or are connected to. In order to create a workable level of such trust and therewith durable adoption, one will need to have comfort, the offer will need to be credible and usable. In that scope, concepts such as ethics, safety, accountability, security and privacy by design have to be widely spread from the early stages of development for IoT products, services, applications, solutions infrastructure and ecosystems. To enable large scale deployments of IoT systems ensuring massive and durable user adoption, it will be essential that IoT and related IoT ecosystems are based on complementary architectures based on similar principles, enabling to leverage across multiple use cases and to catch the extra value arising from information exchange across multiple sectors/domains.

The goal of the CREATE-IoT project is to put in place an approach that can federate the IoT Large-Scale Pilots and, beyond them, other IoT and related ecosystems that are deployed worldwide. Given that IoT applications are meant to affect the living environment with minimum involvement from the human side, security breaches may have direct impact on human safety, and the privacy may be compromised by communications that happen without being noticed. Furthermore, security in IoT environment is more challenging to be achieved than in the traditional Internet of computers, due to power, bandwidth and computing constraints. Therefore, it tends to be neglected in early deployments despite its high criticality. In addition, the privacy risk requires specific overall horizontal attention across initiatives, because exposure of multiple anonymized data about the life, from home energy consumption to public transport infrastructure usage and office activities, facilitates link ability to individual identity, eventually compromising the privacy of each anonymous data. These aspects deserve specific attention in the supervision activities. There are many new ethical, legal and related questions and queries that need to be structured, addressed, clarified and sometimes rethought. There are many layers in any IoT vertical and horizontal matters such as for instance (personal) data protection, data management, security, product liability and net neutrality rise not once, but actually several times per layer. There are quite some layers necessary in order to build an IoT vertical, let alone the many cross-vertical data value chains and liabilities that need to be addressed.

CREATE-IoT has an important and critical impact on potential barriers, on providing the stakeholders with multi-angle and sufficient knowledge, with a trusted environment for the development of IoT, and with comprehensive technical and non-technical practical landscaped guidelines, mechanisms, best practices and other legal and related knowledge, and on giving support to projects across the IoT Focus Area. The ultimate aim is to create the Trusted IoT concept.

CREATE-IoT's expected impact is in ensuring that start-ups, developers and SMEs are able to play a role in the new IoT paradigm. One of the requirements is that the platforms deployed across the IoT Focus Areas must be open to enable sustainability and continued innovation and development of new cases. By ensuring that there are appropriate support mechanisms for SMEs and start-up participation, CREATE-IoT is working to:

- Enable start-ups and SMEs to engage with the IoT Large-Scale Pilot projects and build the skills and technology base they need to be part of the IoT ecosystem.
- Provide clarity about legal considerations on privacy and other related topics.
- Invite disruptive innovation from stakeholders who have no proprietary technology or legacy considerations.
- Ensure that the voice of smaller and new businesses across Europe can be heard in the debates on standards and interoperability.
- Lay the foundations for truly open (although not necessarily free of charge) platforms that withstand changes in any given ecosystem.

The longer-term impact of the support to SMEs is seen in Europe's ability to compete on the world stage with new companies that can contribute to the creation of skilled jobs and economic growth. CREATE-IoT creates impact through the development and implementation of a methodology to integrate artistic practices and creation in IoT innovation, adoption and market penetration. The exploitation of the combination of ICT and the arts has direct impact on IoT Large-Scale Pilots and Focus Area by enhancing a bottom-up user adoption and introducing a critical approach to technology in the design, development, dissemination of new products, technologies, services and experiences in various IoT application domains.

The expected impact resulting from the combination of ICT and the arts can be summarized in few points:

- Increased user adoption and confidence in IoT systems and IoT Large-Scale Pilots thanks to the consideration of user-centric methodologies and consumer-citizens assessment while emerged in IoT systems and experiences.
- Boost of socially driven innovation processes in IoT thanks to co-creation methodologies and a solid critical approach enabled by artists attributing meanings to technologies.
- Enhanced promptness to innovate and enhanced EU ICT competitiveness driven by the emerging hybrid field of ICT and the Arts supported by the EU Digital Agenda STARTS initiative.
- Consolidation of an EU IoT Art-Science cluster of practitioners that can extend the impact of CREATE-IoT beyond its time frame and scope.

8.8 U4IoT – User Engagement for Large Scale Pilots in the Internet of Things

This chapter presents the U4IoT Coordination and Support Action which aims at supporting end-user engagement in the five European Large-Scale Pilots. It comprises a short introduction of the project objectives followed by a review of the various strands of work aimed at achieving those objectives including enshrining participants' right to privacy and the protection of their personal data.

8.8.1 Introduction

U4IoT will support the Large Scale Pilots (LSPs) funded by the European Commission in the context of the Horizon 2020 research programme. It will enable a citizen-driven process by combining multidisciplinary expertise and complementary mechanisms from state-of-the-art European organisations. It will also analyse societal, ethical, and ecological issues related to the pilots in order to develop recommendations for tackling IoT adoption barriers including educational needs and skill-building.

U4IoT combines a wide range of knowledge and experience from a number of leading European partners in end-user engagement through crowdsourcing, Living Labs, co-creative workshops, and meetups designed to support end-user engagement in the Large Scale Pilots. Its strategy is built on four main sets of activities. It will:

- Develop a toolkit to facilitate the LSPs' end-user engagement and adoption activities including: online resources and tools for end-user engagement; privacy-compliant crowdsourcing & crowdsensing tools and surveys to assess end-users' acceptance of the pilots; online resources and an innovative game that will promote awareness of privacy and personal data protection risks with guidelines on personal data protection;
- Support and mobilise: end-user engagement through the training and supporting of the LSP teams so that they may organise their own co-creative workshops; meetups; training on the use of crowdsourcing & crowdsensing tools in an efficient and privacy-friendly way in line with IoT Lab[12] tools; the presentation and facilitation of Living Labs support; an online pool of experts for end-user engagement; online training modules.
- Analyse societal, ethical, and ecological issues related to the pilots' end-users and make recommendations based on the analysis of IoT adoption barriers and how to tackle them including education and skill-building. It will leverage on end-user interactions to design participatory sustainability models that can be replicated across LSPs and future IoT pilots.
- Support communication, knowledge-sharing, and dissemination including: the development of an interactive website with an online toolkit as well as online knowledge database on lessons learned, FAQs, solutions, and end-user feedback. It will support the end-user communication and outreach strategies for LSPs and will enable information-sharing and retro-feed towards LSPs and their end-users.

8.8.2 Engaging End-Users throughout the Life of the LSPs

One of the key objectives of U4IoT is to support and promote end-user engagement across the entire lifecycle of the Large Scale Pilots from design, to implementation, through to assessment. More specifically, the project will encourage and support:

[12] www.iotlab.eu

End-user engagement in the design phase of the LSPs
U4IoT will provide methodologies, such as the co-creative workshops, that will enable pilots to involve the local end-users from the beginning of the project.

End-user engagement in the implementation phase of the LSPs
U4IoT will provide a complete set of tools to actively engage end-users in the design and implementation of the pilots' products and services.

End-user engagement in the exploitation and assessment phase of the LSPs
Privacy-friendly crowdsourcing and survey tools will enable the pilots to monitor end-user perception and acceptance of their projects during the implementation phase. It will enable the pilots to identify issues that need to be addressed so that they may maximise end-user acceptance and satisfaction.

This comprehensive approach is illustrated in Figure 8.24 below.

8.8.3 Embedding Personal Data Protection by Design

U4IoT will adopt a privacy-by-design approach. It will comply with the new General Data Protection Regulation as well as other complementary

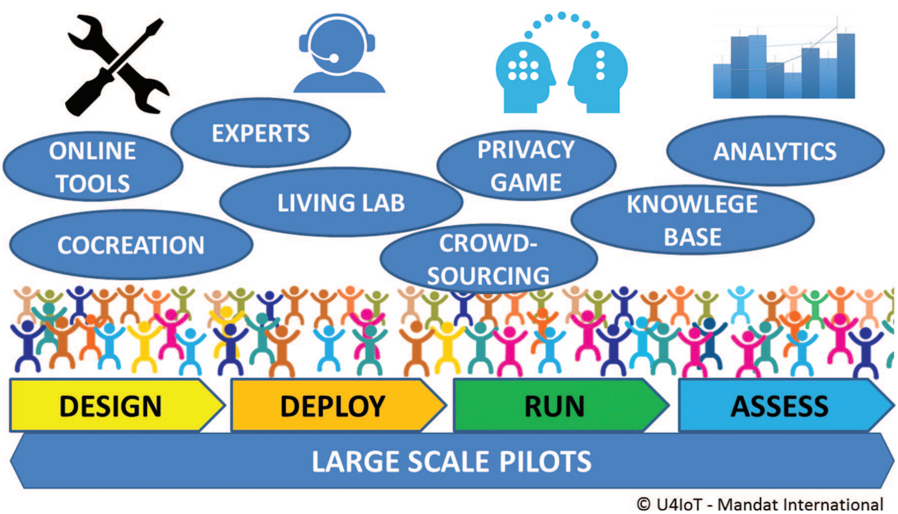


Figure 8.24 U4IoT overall concept.

international (UN-, ITU-, and OECD-related norms) and European standards. These include the Charter of Fundamental Rights of the EU (arts. 7 and 8), the Treaty of Lisbon (arts. 16, 39, 88, and 169), Directives 95/46/EC, 97/66/EC, 2002/58/EC, 2002/21/EC, 2009/140/EC, 2009/136/EC, and Regulation(EC) N°45/2001.

U4IoT not only features expertise in personal data protection, but also has experts on gaming methodologies. One intended outcome will be the creation of a game whose aim is to raise awareness on privacy in connection with the Internet of Things. This will help to better connect with end-users and raise awareness of personal data protection issues and challenges they will face as the technology achieves greater social penetration.

8.8.4 Developing an Ad Hoc Toolkit for End-User Engagement

U4IoT is developing a customised toolkit for end-user engagement in the Large Scale Pilots, including:

Online resources for pilots including tools for end-user uptake
U4IoT will identify, gather, and provide relevant tools and online resources for end-user engagement including strategic guidelines and steps for user engagement and a pool of methodologies and tools to be used in different states or steps in product and service co-design and co-creation. U4IoT will provide resources supporting LSPs in engaging end-users in their pilots. The online resources will be hosted on the project website. In addition, U4IoT will compile these resources and advice into a practical handbook for the Internet of Things pilot deployments. The handbook will also be designed to serve future Internet of Things pilots.

Crowdsourcing and survey tools
U4IoT is leveraging and customising the crowdsourcing and crowd-sensing tool developed by the European research project IoT Lab (http://www.iotlab.eu). It enables researchers to collect fully anonymised input and feedback from end-users through a smart phone application in order to assess, fine-tune, and validate end-user acceptance of IoT deployments. It is particularly well-suited for large-scale IoT deployments.

Guidelines and an interactive game for privacy and personal data protection
U4IoT will develop a game to educate and raise awareness on IoT and privacy issues among the LSPs' stakeholders and their end-users. Our goal

is to develop a game that fully integrates some basic concepts of privacy (mainly online and IoT privacy) into a working and enjoyable mechanism through which understanding such concepts becomes crucial to succeeding in the game. Different versions of the game will be considered and an interactive game will be developed in close collaboration with the partners of the project and end-users. The game will highlight key concepts of personal data protection such as: a priori informed consent, profiling, data processing, anonymity, pseudonymity, etc. The game will focus on privacy issues related to Smart Cities and the Internet of Things.

U4IoT website and dissemination
All presentations, documents, online tools, knowledge database, etc. will be made available and maintained on the U4IoT website. Not only will it document the activities of the project, but will also provide tools for interaction with relevant projects and users. The website will be used as a source for other promotion and dissemination channels such as social networks, which will complement end-user engagement activities done “out and about”. To this end, the “mood of the city” kiosk will be used as a means of attracting interest and spreading information about the project and related activities.

Online knowledge database on lessons learned, solutions, and user feedback
Another important element of the project is the development of a knowledge base on lessons learned, solutions, and user feedback. It will be maintained and regularly updated in order to capitalise on experiences and lessons learned. At the end of the project, the knowledge base and online platform will be formally transferred to the IoT Forum who has agreed to maintain it.

8.8.5 Supporting and Mobilising End-User Engagement

Beyond the development of tools, U4IoT considers that direct support to the Large Scale Pilots is required as a complementary measure to enable effective end-user engagement. A set of support actions and services are being developed:

Co-creative workshops
Co-creative workshops can support end-user engagement in the early stages of the LSPs by co-designing solutions in a multi-stakeholder setting. During the workshop, collective knowledge of end-users, local stakeholders, and

experts from LSPs is exchanged, combined, and captured. The co-creative workshop methodology and toolkit enables experts to empathise with the needs of end-users while end-users are empowered to communicate on an expert level. The workshop program results in one or more use cases that are co-created by the participants.

Analysing and converting the qualitative data gathered throughout the workshop leads to a variety of functional requirements that are based on end-user needs, however, designing, organising, facilitating, analysing, and implementing co-creative workshops in LSPs can be challenging. U4IoT therefore aims to offer a co-creative training program to increase end-user engagement during the beginning of many LSPs in the IoT-1 call.

In this training program, experts from different LSPs are invited to learn how to implement and utilise co-creative workshops in their projects. Experts will interact directly with end-users through the co-creative workshops, ideally increasing empathy and leading to more meaningful IoT-related solutions that are based on the needs of end-users. More LSPs adopting the co-creative workshop methodology will lower the threshold for involving end-users in future LSPs and improve our knowledge on applying this methodology in different contexts.

Living Labs methodology support

U4IoT will also provide the LSPs with Living Lab methodology support. Here, the LSPs will get access to guidelines and services online regarding how to apply Living Lab methodologies within the LSPs. Through this, the LSPs get guidelines on how to develop open and user-driven innovation ecosystems that support end-user engagement in the IoT pilots from the early phases and throughout the whole pilot. In relation to this, U4IoT will provide dedicated on-demand advisory support for the LSPs in Living Lab approaches. This methodology support will mainly be provided as an online tool with webinars and online supporting services.

Online pool of experts for end-user engagement

The U4IoT online training programme will assist LSPs to set up and deploy an effective end-user engagement strategy. The components of the programme consist of an interactive flow-diagram, e-courses, example materials, and an expert pool. The online pool will be a list of experts with details of their specific expertise. The pool will be available online and is part of a front-desk that also contains a list of end-user communities for open calls and a list of FAQs. The LSPs can use the list to contact experts directly for questions and answers or for custom advise and coaching on end-user engagement.

8.8.6 Recommendations on IoT Adoption and the Sustainability of IoT Pilots

Tackling IoT adoption barriers

U4IoT will start by analysing societal, ethical, and ecological issues related to the pilots with end-users and develop a set of corresponding recommendations. This will be achieved by analysing IoT adoption barriers and provide guidelines for tackling these barriers, including educational needs and skill-building.

Sustainability models for IoT pilots

U4IoT will design sustainability models for the LSPs. These models are participatory and leverage on end-user interactions by involving not only the LSPs themselves, but also their various stakeholders and target audiences, from companies to public organisations to citizens. The U4IoT sustainability models will be designed to help the LSPs and their stakeholders, but can also be replicated in future IoT pilot deployment throughout Europe."

8.8.7 Collaboration, Outreach, and Dissemination

A key factor of success for the project resides in its capacity to outreach towards the relevant stakeholder. The collaboration, outreach and dissemination strategy is threefold:

Cooperation strategy with the LSPs

U4IoT will work in close interaction with the LSPs and will offer its support to each LSP consortium from the beginning of the project. U4IoT will organise joint meetings and ad hoc training activities for all LSPs. In parallel, U4IoT will collaborate closely with the other CSA and the European Commission.

Cooperation strategy with the IoT Ecosystem and the IoT Forum

U4IoT will work closely with the IoT ecosystem and will contribute to the visibility and outreach of the LSPs. U4IoT will also work closely with the IoT Forum (chaired by MI), the AIOTI, the IERC, the ITU, and IEEE (more details in Section 8.2).

The IoT Forum will play an important role in supporting the interaction with the IoT research community, as well as in ensuring a long-term exploitation and maintenance of the U4IoT online tools and platform.

End-users outreach, engagement, and active involvement
U4IoT's main users are the consortia leading the Large Scale Pilots implementation. The prime focus of U4IoT is to enable active participation and engagement of final end-users in the pilots. Beyond the end-user engagement methodologies provided and developed in coordination with the pilots, U4IoT will also provide transparent information on its website with resources made available to final end-users too.

8.8.8 A Systemic and Cybernetic Approach for End-User Engagement

Through its aforementioned activities, U4IoT is following a fully integrated and systematic approach. It intends to follow and enable a virtuous cycle by collecting and internalising the feedback from the various stakeholders. The model adopted by U4IoT is summarised in Figure 8.25.

The analytical part is central and enables us to develop the knowledge, adapt and improve the support, and fine-tune the tools. These elements are then applied to the LSPs. The results are then monitored and analysed, closing the loop.

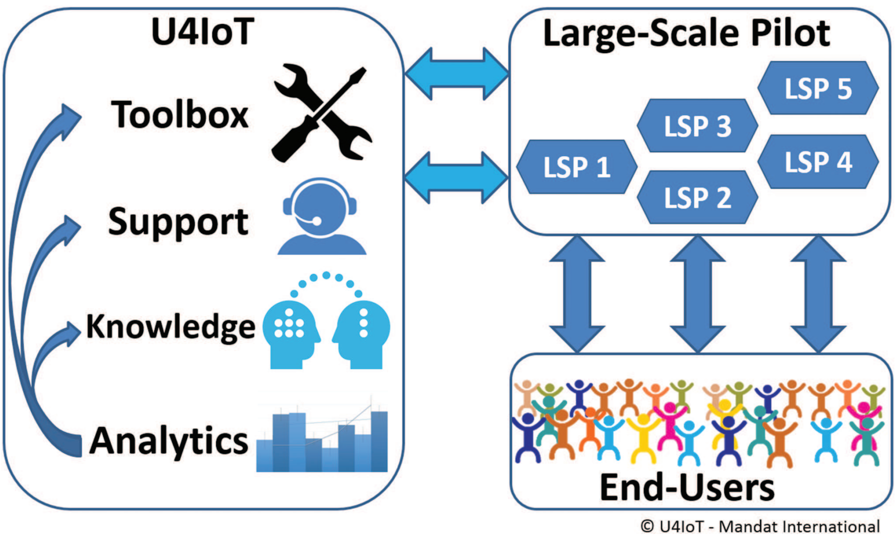


Figure 8.25 U4IoT General Methodology.

8.8.9 Discussion

U4IoT stands as the primary support that the LSPs of the IoT-1 call will use to engage with their audiences and develop deep connections with their end-users. This will be achieved largely due to the extensive experience and knowledge base of the U4IoT partners, which they will provide to the LSPs both offline and online. Continuous support will be provided through our online portal and via an expert pool that will cover all the relevant topics and issues that the LSPs are likely to face in the realm of end-user engagement.

Expert knowledge will be accompanied and underpinned by technical tools including state-of-the-art crowdsourcing technology, by a robust legal framework, and by innovative engagement methodologies such as the privacy game and co-creative workshops. All of this will be achieved while simultaneously accounting for societal, ethical, and ecological considerations.

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