AIOTI

ALLIANCE FOR INTERNET OF THINGS INNOVATION

Smart City LSP Recommendations Report

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1 Introduction

Towns and cities across the European Union (EU) provide a home to more than 70 % of the EU-28's population. Cities, in particular, are seen as both the source and logical solution to economic, environmental and social challenges and are therefore central to achieving the Europe 2020 goals of 'smart, sustainable and inclusive growth' in Eurostat terms.

By using the IoT technology the distinct pillars of the modern city (energy, mobility, buildings, water management, lighting, waste management, environment, etc.) need to migrate to become part of a structured, interconnected, ecosystem supporting the humans that the city is built to serve. They must do this while maintaining security and privacy and also reducing cost, emissions and energy consumption while being reliable, long lived, future proof and scalable. Further, this migration must take place while the city is active – subsystems controlled by different stakeholders and industries must be aligned on the fly, in order for a Smart City concept to be developed which can be reproduced elsewhere.

The Alliance for Internet of Things Innovation (AIOTI) was launched in 2015 by the European Commission and several relevant stakeholders (mainly industry) in the IoT domain to create a dynamic European ecosystem that can boost the market in its multiple application domains. As part of the Horizon 2020 work programme for 2016-2017, there will be a specific call for Large Scale Pilots in the area of Internet of Things. One of those LSPs will be devoted to smart cities (*Pilot 4: Reference zones in EU cities*). The AIOTI Smart Cities Working Group has gathered inputs from its partners, identifying four main areas of action, existing development gaps and the related technological requirements needed for LSP deployment.

The aim is to create a city centric ecosystem of state-of-the-art, viable, technologies which apply the IoT technologies and integrate it with the concepts of Internet of Energy (IoE), Internet of Vehicles (IoV), and Internet of Buildings (IoB) to increase the efficiency of the city by enabling unobtrusive, adaptable and highly usable services at the network-edge, gateway and cloud levels.

The LSP will address a diversity of stakeholders with disparate needs and agendas, including citizens, professionals, infrastructure workers, companies and institutions. These stakeholders will have different, and perhaps contesting, requirements and the services need to address multiple multi-domain IoT applications.

To fully exploit the LSP results will require a multi-national vision supported by regulatory action and sustainability. Significant resource need to be dedicated to demonstration, exploitation and IPR management activities to achieve this. The LSP will have an immediate impact on use cases correlated with several other IoT application domains i.e. energy, mobility, the management of resources during utilisation (parking, fleet management), etc.

The approach used in the LSP need to be applied both for re-development of existing cities and for green field deployments. Crucially, the approach should recognise that there is a migration necessary from the "Legacy City" to the "Smart City" and the IOT technology will support this stepwise migration without disproportionate upheaval.

There is a need of a combined top-down, bottom-up approach, where the city and the end users can define the IoT applications requirements and specifications and where the pillars of the smart city are connected for mutual benefit is very novel, and it allows for the coordination,

monitoring, control and sharing of information. Simultaneously the IoT technology providers at the application level will offer hardware, communications infrastructure, software, middleware, and Internet based platforms that will deliver all of the essential capabilities for seamless, secure, trusted and safe connectivity and interoperability. Taken together, these actions will generate enough accumulated synergy effects to make the city really smart.

The LSP is aimed at TRL 7 solutions for development of city IoT application specific sensors/actuators, nanoelectronics, communication, cyber-physical systems, software and cloud platform technologies and building blocks and subsystems based on adopted or modified existing components.

The LSP links with the smart cities European Innovation Partnership, the Energy Efficient Building, Smart Cities and Communities and Internet of Things and Platforms for Connected Smart Objects initiatives under Horizon 2020.

The goal of the LSP is to develop and deploy the IoT technology that will support the city to be developed as urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas: economy, mobility, environment, people, living, and government. Additional objectives will be twofold: on the one hand, to foster the establishment of a IoT'ed Smart Cities market in Europe, where previous results on open platforms for IoT (as FIWARE and FIRE) can be used to improve interoperability among solutions; on the other hand, to provide real examples of how new IoT demand side centred services can be implemented and delivered.

As part of the AIOTI, the Smart Cities Working group has produced an analysis and a set of recommendations considering the point of view of the industry and other relevant stakeholders. The basis of these recommendations come from the following features that a successful LSP project has to fulfil:

- a solution that solves a real-existing problem / need [for citizens or users];
- assessed as valuable by citizens and communities;
- scalable to the whole city;
- demonstrated replicability in other cities and interoperability in the city;
- sustainable from environmental, social, economic, and financial point of view;
- and ability to thrive local economy (SMEs & entrepreneurs).

Following the whole IoT LSPs programme identifies challenges, the recommendations have been identified following three major topics: technology, paying especial attention to interoperability and trust and security issues; acceptability, focusing on how to meet citizens and users' needs and expectations; and business, providing insights about how to provide evidence of the midterm sustainability of the projects.

2 Technologies and platforms

2.1 Current state of technologies in the Smart City domain

Technological support is essential to the operation of the modern city – there is simply no way that such numbers of people could live in close proximity without technological mechanisms to support them. At the moment these systems are largely independent pillars; cities have separate systems for mass transit, lighting management, power distribution, emergency service delivery, food distribution, waste collection and management, environmental monitoring and a multitude of other functions, where similar capabilities are often duplicated in each pillar. It is therefore clear that there are considerable cost savings and performance improvements to be gained by coordinating and seeking common platforms for integration of duplication for these separate and distinct systems.

The Smart City of the future should be capable of many of the functions we normally associate with a living entity; it will need to sense its own state, identify unusual or threatening circumstances and then create and execute plans to maintain citizen safety and its own functionality. Doing this requires highly scalable, connected, systems capable of sensing, acting, controlling, balancing and forecasting in an environment which is uncertain and unpredictable.

In this context, the Smart City is becoming one of the biggest fields of application for IoT technologies. Cities are more and more full of devices equipped with sensors, actuators and other appliances providing information that in the past was either impossible or relatively difficult to gather. Their main purpose, among other functionalities, is to gather information about various parameters of importance for management of day-to-day activities in the city as well as for longer term development planning. Examples of such parameters are information about public transport (real-time location, utilization), traffic intensity, environmental data (air quality), occupancy of parking spaces, noise, monitoring of waste bins, energy consumption in public buildings, etc.

In order to accomplish this task, a variety of technologies have been deployed to meet the requirements of each particular application (expected range, energy consumption, bandwidth needed and many other variables). Thus, the range of technologies being used in a Smart City environment is wide and covers several levels, ranging from the physical level to the data and applications layers. Nonetheless, the current scenario in the Smart City domain is one where there are several available technologies for solving similar problems with no clear winner or general consensus on the best options to solve a given issue, at least in the short term[1].

In addition, so far, smart city initiatives and pilots in general were to a large extent focused on creation of smart infrastructure, deploying sensors, applications etc. However, smart infrastructure on its own is not sufficient – creating a real impact will be possible only by actively engaging and involving citizens into management and planning of the cities.

So the next step in devising an LSP should be to focus on:

[1] A table summarising some of the technologies applied in the Smart City can be found at Annex I.

- Finding novel ways to attain interoperability to avoid vendor lock-in and reach added value proposals by combining the available options.
- Identify new ways to exploit the high amount of data provided by the IoT infrastructure in order to create greater opportunities to innovate.
- Leverage ways for the stakeholders of the Smart City to participate and provide adequate tools to facilitate citizens in getting involved, collaborating and contributing to become part of the IoT ecosystem.

2.2 Areas for action and LSP technological requirements

2.2.1 Interoperability at Smart City levels

The LSP needs to adopt a holistic, integrated, approach that combines edge devices, sensors/actuators, hardware, software, communication, cyber-physical systems, edge computing, cloud and platform technologies into an IoT technology and innovation ecosystem that integrates and converges individual solutions in the city pillars of energy, lighting, home/buildings, and mobility, while maintaining the invariants of interoperability, trust, safety, security and privacy.

Interoperability at several degrees (syntactic, semantic, etc.) is a crucial aspect to take into account in a Smart City environment where solutions from several vendors, different protocols and hardware devices coexist. Due to this fact, several gaps have been identified regarding the achievement of an interoperability model in past initiatives and Smart City pilots:

- Problems have been detected in the past integrating sensors and devices within the Smart City network infrastructure and platforms from several vendors due to the lack of standardization.
- Difficulties connecting end devices (sensors) to the backbone network and the Internet have been found in several deployments.
- Connecting IoT devices to legacy systems and interoperability between legacy systems in general has been problematic due to the use of obsolete or badly documented technologies.

Thus, a Smart City LSP will need to take into account several requirements in order to achieve interoperability:

- Pilots should be able to achieve interoperability and avoid technological silos.
- Proper mechanisms such as capillary networks will need to be deployed in order to correctly ensure communications between end devices and backbone/telco networks.
- When possible, and when making new deployments, common open hardware software and standards should be used to avoid vendor lock-in. However, as many cities have already deployed a communications infrastructure, interoperability at the data level will help to achieve interoperability independently from the underlying protocols or hardware.
- Interfaces, APIs or other means to access data should be clearly defined. Open and Agile Smart Cities (OASC) principles constitute a practical example of how interoperability can be achieved.

The LSP aims to deliver standards based interoperability solutions for middleware and cyber-physical systems, enable new functionalities through interconnection (for example systems for

traffic management and protection of the environment) while protecting the privacy of the users.

2.2.2 Data openness

Currently, large amounts of data are being generated by a variety of sources in a Smart City, especially IoT devices. But, how can administrations, citizens or companies make the most of all these data? Some problems include:

- Lack of involvement from administration and companies unwilling to show data to the public.
- Problems inside the administration and unwillingness to share data between departments in some municipalities.
- Lack of knowledge of business cases for opening data from the public administration perspective.

The philosophy of Smart City pilots should be based on open platforms and sharing information to the public when possible and privacy is not compromised. Hence, several requirements can be envisioned to solve the previous problems:

- Whenever possible data access should be given to citizens, organizations and administrations. Open data platforms should be used for these purposes while taking also into account privacy measures with critical data.
- Open source collaborative technologies should be used to avoid proprietary design from scratch. This measure will help in the standardization of tools between cities.
- Data openness to the public and companies will help in problem solving by leveraging citizen participation, using online tools that let people debate ideas, generate innovative solutions and discuss about them. In the end, this will increase the participation of the population in the Smart City planning through open governance.
- Open data does not mean “free of charge”. Defining the current business model and data monetization plans should be part of the requirements.
- Open common mechanisms to access data, as those proposed by OASC, could be promoted from cities and platforms.

2.2.3 Privacy and security

The evolution being experienced in the development of Smart City services, platforms and tools implies not only a way to create new opportunities from several points of view (economic, social, governance…) but also new security challenges and privacy risks that must be solved. Several problems can be detected, especially for large scale deployments:

- Inadequate Security policies (incomplete, or not clear and concise) for transmitting or storing data to protect it from unauthorised hacking.
- The use of concepts such as that of open data introduces challenges to ensure data is protected from being used by anyone in ways which data subjects have not consented to or would be uncomfortable with.
- Most municipalities or agencies are uncomfortable with sending data to cloud storage and computing systems as they believe control over it is lost in unsecured services. They prefer to keep data in local servers using cloud systems as pass-through.

- There are clear challenges attributing data ownership and protecting the privacy of information shared by citizens. Moreover, when sharing data in large scale deployments there is a risk that privacy rights can be jeopardised due to cascading.

Given these challenges, a Large Scale Pilot for Smart Cities should take into account the following aspects:

- Use of Security by design principles: the system needs to be designed with security in mind from the beginning and at several layers. It needs to make use of appropriate security given the likelihood of risk and its consequences, taking into account integrity and protection of data, equipment, networks and applications. It needs to be upgradable over the air.
- There must be clarity over how any data is likely to be used, and this should be made publically available, unless there are specific reasons for not doing so. Moreover, if personal data is combined with sensing or other information collected by deployed sensors, privacy of personal information shall be preserved if the resulting data is going to be forwarded to third parties through anonymization techniques. (Guarantees to keep data anonymised might be required.)
- Systems extracting information from images or other privacy sensible sources are common in Smart Cities. For such, local processing is to be encouraged to avoid sending sensitive information over the network. Acceptability from citizens will be easier for systems computing and transmitting anonymized data rather than, for example, generic video data to the cloud.
- Security and access right management may be supported by Smart City systems to provide information only to authorized users if required, despite no risk on privacy. Appropriate measures should be taken.

2.2.4 Efficient use of resources

In a general manner, one of the main objectives for cities' municipalities is to make a more efficient use of resources (water, electricity, wastes, etc.). Smart Cities aim to accomplish this task by applying novel technologies to reach a better sustainability. Thus, from a technological point of view, an efficient use of several resources has to be made also in order to reach this objective. Several aspects can be detailed:

- Smart Cities infrastructures have been traditionally rigid and with problems to support a scalable and efficient deployment of new services due to equipment incompatibilities, lack of planning or administrative problems.
- Past initiatives, despite proposing several actions to improve resource efficiency in Smart Cities, have not achieved a level of sustainability that would enable the creation of new opportunities to foster innovation.

With these gaps in mind a Smart City LSP should take into account the following measures:

- Devise new models for an efficient, sustainable and resilient infrastructure deployment while taking into account already deployed systems.
- Find novel and innovative ways to leverage resource exploitation in the Smart City and unlock new models for technological development. For example, the use of smart methodologies to save energy in street lighting or other electric systems can help to save money that can be reinvested into new technological advances in other Smart City domains.

2.3 Standardisation

The IoT LSP deployment plan should be developed around the concept of technology and urban private-public partnerships that will be used catalysts to unleashing tech-based innovation, entrepreneurship and economic development.

The IoT LSP demonstration cities should be used by the project as centres of innovation; piloting and testing new IoT solutions to disseminate and exchange ideas on best practice that can be scaled and replicated at European and international levels.

The technical prototypes developed in the IoT LSP will serve as commercial promotion to demonstrate the different sensors/actuators, hardware, software, communication, cloud, IoT platform technologies in the city pillars and the results will be presented to public authorities and stakeholders to demonstrate the technical and deployment capabilities.

The project will be involved in standardization activities addressing IoT in AIOTI WG03, Smart Cities in ETSI, CEN/CENELEC, ISO, IEC, ISO/IEC JTC 1 and ITU-T. The terms of reference of CEN/CENELEC/ETSI working group on smart and sustainable cities and communities, ISO/AG-Smart Cities, IEC/SEG 1-Smart Cities, JTC 1/SG 1-Smart Cities and ITU-T FG-SSC all incorporate basic tasks addressing the definition and taxonomy, smart cities landscape/framework/reference architecture, gap analysis with other standardization activities and new standardization opportunities and their roadmap. The following AIOTI documents *"IoT Landscape and IoT LSP Standard Framework Concepts"*, *"IoT High Level Architecture (HLA)"*, *"IoT Semantic interoperability"* may serve as guide for the standardization activities of the LSP, from the identification and selection of SDOs and Open Source initiatives to contribution to new or existing standards.

2.4 Technological recommendations

Support an incremental and scalable deployment of infrastructures	
Description	Usually, infrastructure deployment and configuration (telco networks, civil infrastructure, grids...) is costly for cities. Thus, as far as possible, cities will need to apply several measures to ensure sustainability when implementing smart services in order to enable scalability and replicability: ● Modular architectures should be designed and implemented, enabling easy ways to interface with already existing infrastructures by using standards, protocol wrappers or other innovative means. ● Infrastructures should ease the introduction of new functionalities and be easily expandable to support new use cases and user needs. ● Increasing the intelligence and flexibility on end devices will help them to take autonomous decisions, decreasing resource overloads such as bandwidth and improving their management. A way

	to achieve this is by enabling an easy remote access to end devices to configure them.
Rationale	Most cities have some kind of infrastructure that allows them to control, manage and observe the performance of city services. Nonetheless, these infrastructures are frequently too rigid to be easily extended to other city areas, to set up channels with other cities or to adapt their features depending on the context and the needs of the environment.
Examples	The city of Singapore has deployed an infrastructure with several gateways (iAG Box) that provide network connectivity and power to sensor and network deployment while enabling multiple agencies to share this common infrastructure.

Enable interoperability at the data layer	
Description	Interoperability can be achieved at various levels, starting from devices/IoT communications. However, sources of data in the city are various and heterogeneous and it is not always possible to interact with IoT devices directly, but through third party systems. Interoperability will be then preferably achieved at the data level, considering: ● A unified API for accessing data independently of the protocols, APIs and models supported in the underlying IoT platform in a machine readable way. ● Unified models as much as possible in key verticals to enable easy data consumption from different sources.
Rationale	There is a lack of market of Smart City/IoT solutions due to the lack of widely used standards. This harnesses not only interoperability inside the city, but also the replicability of solutions among cities.
Examples	Open and Agile Smart Cities promotes interoperability through three major elements : an open data platform as CKAN, an in-time data API for context data in the city (NGSI) and shared data models for the various verticals of a city on top of that API.

Use existing open specifications to foster innovation	
Description	The use of common open and well documented specifications in a Smart City LSP provides a way for developers, companies and citizens to access IoT services, data or tools in a universal manner. Thus, an open philosophy will ease the process of establishing common ground at large scale between cities with different needs and characteristics On the other hand, data openness policies will be desirable to find new uses for datasets and enable citizens and small companies to create novel and innovative uses from information coming from a disparity of sources.
Rationale	One of the main characteristics of Internet of Things deployments is the heterogeneity of devices, solutions and ways to obtain data. The use of open specifications provides a way to create an open method for achieving collaborative development where all the stakeholders are able to collaborate to create new and innovative solutions rather than having an environment controlled by closed solutions from specific vendors with little accessibility.
Examples	Relying on open platforms, especially those resulting from European programmes, such as FIWARE and FIRE, can enhance interoperability and portability of solutions.

Enable a configurable and adaptable privacy and security framework	
Description	A Large Scale Pilot will take place among cities located in several countries with differences in mandatory privacy policies and security measures. In addition, each one of these cities may have its own ecosystem of platforms, infrastructure, devices and technologies. Thus, to overcome this issue the pilot should provide a security and privacy framework that: ● Ensures a basic level of compliance of EU legislations and policies regarding privacy and security. ● Can be easily adapted and tuned to the requirements of each specific environment considering existing legislations and technological approaches. ● Simplifies complexity so it provides a means for Smart City users to easily control their personal data.

Rationale	Although there are some common policies regarding security and privacy protection at the European level, each country has its own specific legislation and national measures. Moreover, the high heterogeneity of IoT solutions present in a Smart City environment implies that a wide diversity of security and privacy challenges must be overcome.
Examples	RERUM and SOCIOTAL are two European projects aiming to solve the challenges of security and privacy in heterogeneous Smart City environments with high social participation. Regarding data accessing, there are strong efforts from the EC in e-Id projects (e.g. STORK). Promoting the use of such technology will simplify the way one application developer can access to different repositories from different cities.

3 Acceptability

A smart city is a developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas: economy, mobility, environment, people, living, and government[2]. On a more technical level, a **smart city** is defined as one that has "*deployed-or is piloting-the integration of information, communications, and technology (ICT) solutions across three or more functional areas of a city."*

In this context, Large Scale Pilots are essentially new technological actions. Their goal is to design, and create solutions that essentially will create or improve citizen's services, either through improving their quality of life or by making more efficient usage of resources, while creating ecosystems of stakeholders that are testing various technological solutions and business cases. While the focus of Smart City projects in the past has been on many occasions driven by technological goals, in LSPs users and citizens should become the main focus. There is a need to find evidence of acceptability of the results of a smart city pilot through KPIs that reflect citizens life and not only economic or efficiency parameters.

Public city environments are complex and large. The only possibility to address these large-scale, multi-subsystem projects is in a collaborative, open-innovation context, where effort is required to align interests, shape opinions, develop business models and provide a common, interoperable IoT technology ecosystem. The focus of LSP is therefore to provide a route toward this common ecosystem for a wide variety of city focal areas, technology pillars, and citizens.

3.1 Users and Citizens

Cities are "used" by people, which play different roles on the city (resident citizens, visitors and tourists, businesses, municipal services employees, etc.).The focus on users and citizens can be orchestrated in various dimensions: problems, awareness, participation, culture and digital transformation.

Cities organize through multiple verticals, often silos, where infrastructure and data is managed by different municipal departments or in most cases utility companies, very often in an isolated way. This is usually an efficient way of managing certain services. However, when focusing on citizens and users' needs and problems, these are rarely managed or solved by a unique vertical and they are often cross cutting. Moreover, providing a multi vertical integrated view of the city can help municipalities to improve decision taking in the city.

While considering citizens and users in/of the Smart City, the first key element is to handle the communication with them as genuine stakeholders. It is very important to create awareness in the city about the smart city vision and the required/planned investments and actions from multiple perspectives (financial, human and intellectual, environmental, urban, etc.). Beyond the obvious opportunity to on board them in the project, lack of awareness can lead to rejection and hampering.

As part the plans to create awareness in the city, cultural aspects should be considered, in order to promote the changes of behaviour required. This is relevant for citizens in general,

[2] Using Big Data to Create Smart Cities, online at http://informationstrategyrsm.wordpress.com/2013/10/12/using-big-data-to-create-smart-cities/

and municipal employees in particular, for whom special trainings could be needed in order to adopt the technologies, adapt to new or modified processes, and obtain the best from the pilot. Skills on new technologies and data science knowledge could be especially useful for this purpose. All in all, all this cultural and behavioural changes can induct a digital transformation in the city, changing the way live and business takes place in the city.

Involving citizens and users can be achieved in different ways, but from a practical perspective, LSPs should consider them from the design, providing evidence that the proposed solutions (and the problems or needs they satisfy) are based on a real perception of benefit. During implementation, different participation mechanisms can provide added value, e.g. through citizen participation in budget and other types of decisions, notifications of incidents, IoT crowdsourcing to improve or complement official data, or any other ways to involve users, citizens and communities in the assessment of the results.

3.2 Stakeholders

No single Smart city actor can solve the problems in the cities. Problems are cross cutting. This introduces complexity and requires a systemic approach to smart city solutions. As such, the success of a pilot will very much depend on involving the stakeholders in one way or another. From the municipality government, to other local administrations relevant for a testing zone, utilities, technology or service providers or even local businesses, citizens and communities, should find their place around a smart city pilot. Since this approach will not always be feasible, intermediary organizations could also be considered to achieve proper engagement (e.g. NGOs could be useful to engage with non-digital citizens).

From all the stakeholders, there is one type that may also play a relevant role: local stakeholders, both technical (start-ups, entrepreneurs) and traditional (retailers, restaurants, etc.). A LSP may represent the gear lever for transforming the city into a platform, over which a new plethora of business opportunities can arise. For enabling this bottom-up approach in the city, IoT and IoT/real time data can leverage this platform. Open data is a trend that in this context may play an important role, but data market approaches could help monetize investments, and guarantee the quality and reliability of the data that entrepreneurs require.

3.3 Cities

Every city is different and there are multiple dimensions to make evident this diversity: geography, demography, economic and financial situation, culture and ways of living, etc. Moreover, when it comes to technological initiatives (e.g. smart city and IoT), there are multiple strategies, experience, maturity levels, etc. All these bring different problems and demands, and therefore use cases to be solved in a LSP. Considering various factors, a recent benchmark highlighted a number of interesting applications for IoT: mobility, well-being, food tracking (or delivery in the case of a city), work safety, energy saving, personal safety, etc. The EIP on Smart Cities and communities has also identified relevant use cases around the domains of energy, mobility and ICTs.

By applying the results of the IOT LSP European cities can establish cooperation IoT platforms of networking, data, information and knowledge exchange. Having an interoperable, scalable IoT technology ecosystem addressing the urban landscape of a city leads directly to significant cost savings and improvements in implementation consistency, quality and manageability.

The IOT LSP will allow cities to create and deliver better public services faster and more energy efficiently. It will also allow them to collect (suitably anonymised) data that allow the complexities of daily urban life to be better understood and managed.

The approach changes the way that society, the economy and cities evolve and will have enormous implications at the economic, environmental and welfare level by creating growth and improving the efficient use of resources.

The selected problem will lead to the definition of testing areas in the city that will have to be properly selected. The network of cities where this type of solutions will be tested will also have to reflect the importance of the problem from the demand side. At the same time we should not lose the goal of the LSPs: to create a market for the smart cities industry in Europe.

3.4 Recommendations

The IoT LSP comprise technological innovations integrated into new hardware/software modules, algorithms and communication/computing platforms that bring significant technological changes in the application landscape of the city. The expected impact is evaluated through the implementation of the developed solutions in the city demonstrators and the sustainability and replicability of these solutions.

Stakeholders in the testing zone	
Description	All the stakeholders in the value network should be involved in a way or another (e.g. partnership, open calls, challenges, calls for participation, and any other type of engagement). The LSPs have to take advantage of the flexibility of the available tools to engage stakeholders in the best manner: ● Involving from the beginning the key stakeholders as part of the pilot consortium. ● Allocating a (small) part of the budget to open a call for new partners, so that it is possible to identify and engage certain stakeholders once the project has made progress. ● Allocating budget to organize challenges, hackathons, evaluation and assessment processes, etc.
Rationale	Not involving key stakeholders can spoil the success of a LSP. Utilities are critical for integration of vertical silos / services. Citizens are not only the most important recipient of the results, but can easily become hostile to the project. In some testing zones, many services and infrastructures will be managed by non-municipal organizations, etc. But the city must engage with all the stakeholders within the test zone to guarantee the proper participation in the project.

Examples	Key stakeholders in a testing area or for a given problem include: • utility companies offering public services under contract with the municipality • citizens and communities • public and non-municipal bodies (Universities, Health, Army, etc.)

Define common problems in representative cities and networks	
Description	Although different cities all over Europe will have very specific problems (may be shared with some others), in order to guarantee the replicability of results, the problems and scenarios selected for the pilots should as much as possible concentrate on problems with a wide common ground in European cities. For each of the cities solving a problem, a testing zone has to be defined. This is a place where you have the technical and legal conditions to deploy and validate the solution of a "top problem" of a city. Testing zones will be usually physical areas in the city and in order to be well designed they should be: • small enough to be feasible, taking into account the required resources (infrastructure, deployment, etc.) and engagement of stakeholders; • large enough to be significant, guaranteeing that the results can lead to conclusions that can be shared with other cities and become the basis for further commercial activities; • generic enough to be scalable, enabling that the results can be extrapolated to other areas in the city or other cities. While different cities have their own particularity, a network of cities trying to solve similar problems in defined testing zones will be the scaffolding of a LSP. A credible network of cities must be: • heterogeneous enough to be a reference at European scale and to demonstrate interoperability. • homogeneous enough to share a "top problem"
Rationale	Every city is different. Geography, climate, size, culture, etc. They share many problems, needs and concerns, but they have their specific challenges. Focussing too much on these specificities could limit the results of the project, understanding that it will be more difficult to scale the solutions.
Examples	Some of the prominent use cases highlighted by the Benchmark Study [3] include smart mobility, food traceability, energy saving, smart living and

	wellbeing, or work safety, as examples of problems commonly shared by cities all over Europe.

Focus on users' and citizens' needs	
Description	LSPs will focus on finding the proper technological solutions for real concerns, problems or needs detected by the demand side (citizens and users and the whole city, including stakeholders), rather than defining problems subject to be solved with deployed or available technologies. In order to achieve that goal, evidence should be presented about the real need of a certain solution and its probable impact. This evidence could be substantiated through direct engagement with users, citizens and communities, and the city itself, including third party organizations that may help to engage with non-digital citizens. As for the validation process, it is key to involve citizens and users in near to real life conditions using the solution provided.
Rationale	Although there is lots of hype on IoT technologies and it is the core technology for these projects, and even though they have to focus on gaps for innovation, a technology driven approach will lead to huge investments without clear return of investment (from social perspective).
Examples	For example, User Experience methodologies could be used to identify needs, design the solution and validate the results. Engagement of citizens and communities could be done through multiple mechanisms (not only project partnership of civic organizations).

4 Business aspects

The deployment of IoT to create 'smart cities' is gaining momentum in Europe, according to a study by Frost & Sullivan, stimulated by the numerous pilot projects running at regional, country and EU levels. Initiatives revolve around energy and water efficiency, mobility, infrastructure and platforms for open cities, citizen involvement, and public administration services. They are co-funded by the European Union through its ICT Policy Support, 7th Framework and Horizon 2020 programmes. The report says, there is no clear business model for the uptake of technology in smart cities, such as smart metering, wireless sensor networks, open platforms, high-speed broadband and cloud computing. Projects are carried out in the form of collaborative networks established between the research community, businesses, the public sector, citizens and the wider community, and they foster an open innovation approach. Smart metering, wireless sensor networks, open platforms, high-speed broadband and cloud computing are all key building blocks of the smart city infrastructure[3].

A successful LSP requires a business framework to ensure that the viable approaches and solutions can scale-up, when appropriate, and can be replicated into other cities throughout Europe and worldwide. An innovative solution will impact in the operational expenditure of a given service or set of services in a focus city area (for instance, by lowering operating costs); it can also impact in the investment as well (for instance, by sharing the same infrastructure for different services) and, by creating a replicable solution, it can lower the cost per implementation.

A McKinsey Global Institute analysis suggests that just the top 600 cities (defined by their contribution to global GDP growth to 2025 – a group they call the City 600) will generate nearly 65% of world economic growth in this period4. Modern cities compete with each other to attract businesses, talent, skills and taxpayers. As a result, administrations are becoming entrepreneurial, valuing innovation, technology, marketing and communication. In turn, businesses are attracted into cities by the ease of operation that they offer, in terms of cost efficiency, infrastructure (office space, broadband, telecommunications, as well as utilities such as energy, water and transportation), and general quality of life for staff (residential, healthcare and education systems).

Smart city technologies are being developed to address a range of issues, including energy management, water management, urban mobility, street lighting, and public safety. These innovations are underpinned by general developments in wireless communications, sensor networks, data analytics and cloud computing. The smart city concept is also driving new integrated approaches to city operations; Navigant Research forecasts that global smart city technology revenue will grow from $8.8 billion annually in 2014 to $27.5 billion in 2023.

This Navigant Research report examines the evolution of the global smart city market, detailing the impact on key technology markets, including smart grids, water management, transportation, building energy efficiency and government services.

[3] Building smart communities, online at http://www.holyroodconnect.com/tag/smart-cities/
[4] Urban World: Cities and the Rise of the Consuming Class, 2012 http://gt2030.com/2012/07/17/urban-world-citiesand-
the-rise-of-the-consuming-class/

New city development is a powerful economic driver for innovation. Smart infrastructure and the technology development from big data analytics, autonomous vehicles and inductive electric power for mass transit systems, light poles, and multimodal transport integration all contribute to creating a next generation city that is hugely more efficient than what we can achieve today.

The cloud edge computing, federation of clouds and in general the aggregation of inter-communicating web services in a unified service delivery solution allows both large companies and specialized SMEs to publish and monetize their services in a dedicated smart city market with standardized communication protocols and semantics which guarantee compliance security. Such a novel and unified IoT vision will generate a new market for services where small and big players can play an important role.

Cities (i.e, municipalities) consider themselves as engines for innovation and growth and how smart cities activities and business are going to generate revenues remains still unknown. Investing on new technologies and processes is seen as a way to achieve that goal, and not necessarily to provide a given service in the short term. However, a key challenge will be the financial strategy at a time when public budgets are under austerity pressures. An innovative, new city infrastructure with a viable business model should be able to attract new sources of financing, in addition to traditional financial instruments, including the contractual models of Public Private Partnership (PPP) and new procurement models Public Procurement of Innovative Solutions (PPI) and Pre-Commercial Procurement (PCP), These mechanisms can be implemented to engage with additional stakeholders and find the best solutions to solve the problems identified in the project, enabling the enrollment of European SMEs and start-ups.

A business framework that addresses interlinked city needs will have to impact in the current procurement processes and procedures, sometimes implemented in an isolated manner at the city level or too short term oriented towards available technologies and solutions.

Procurement can have the potential to drive innovation along the value chains by creating local ecosystems in a combined business model. A local ecosystem is a market place on city level, in which several stakeholders, local and global industries, large and SMEs, and governments participate in order to achieve value as well as to encourage local innovation and business development that may lead to the creation of new high-technology urban industries.

All in all, it is necessary to identify and implement a number of measurements to ensure that by the end of the LSP, the investments and infrastructures deployed will be sustainable from different perspectives, but mainly from the financial one.

4.1 Recommendations

Demonstrate a clear business case	
Description	The LSP has to demonstrate the business case that justifies the initiative, where: • The direct economic impact (cost savings, time reduction, increased service efficiency, etc.) as well as the possible

indirect effects (such as environmental or social effects, or the attractiveness for new investments), are estimated in several time horizons (short/medium/long-term).

- Investments are clearly defined:
  - new infrastructure deployments should be described in the budget, as well as the affordability of them being integrated into existing ones,
  - a clear statement has to be made about the ownership (city, third parties, etc.) of infrastructures. In case of third parties or PPPs, the terms of the agreement / contracts should be described
  - IPR. Who owns the data.
- Recurrent costs of infrastructure O&M and services operation should be quantified.
- OPEX and CAPEX funding, ownership and IPR.
- The flows of value and cash should be described, in order to understand the sources of funds (services, data monetizing, public budgets, etc.).
- Impact on existing regulations and the potential need for new regulations should be explained.
- In case of public budget, economic, social or environmental KPIs and metrics should be defined to provide evidence of the social and financial return of investment (ROI and SROI) in the specific focus area.
- Future plans for scaling up of the pilot to the other parts of the city (when it applies) or for replication in other city contexts could be provided to demonstrate sustainability.
- Standard and innovative approaches and business plans should be considered for the financial viability models: PPP, Multi-side Platforms (MSP), collaborative economy models, pre-commercial procurement and competitive dialogue, etc. These business models have to be in line with the operation model (how to deliver services) and the finance model (how to finance investments). Public procurement procedures and processes should be considered when defining the business case and, in particular, the cost – benefit analysis.
- Even though the LSP will involve at least 4 main cities, the pilots plan could include how the results are going to be exploited in the countries in the footprint of the technological partners (e.g. other OASC cities in the same country).
- Issues related to current contracts with service providers and utilities in the municipality should be clarified to guarantee the feasibility of the pilot.
- Plans to make an impact within the local ecosystem in the city, involving SMEs, local businesses and entrepreneurs to

	achieve value on top of the city platform and services should be provided. • Pilots should preferably rely on existing infrastructure, platforms and services. Budget constraints could undermine the feasibility of deploy-from-scratch pilots.
Rationale	The limited financial capacity of municipalities imposes to work on innovative funding mechanisms: ● Public-Private Partnerships. The collaboration with between public administrations and private companies to deploy infrastructures, provide services and leverage the innovation can enable the development of new public services and provide mechanisms to attract investments beyond the capacity of municipalities and to ensure the sustainability of the project. ● Multi-Sided Platforms, enabling multiple revenue flows among various stakeholders in the Smart City project and facilitating the economic interaction and value flows among them. This model will allow infrastructure and service providers to investing the city, while the municipality fosters the creation of new services. ● Tax incentives for investments in smart city initiatives to promote private investment. The main goal has to be the return on investment, but not only from an economical point of view, but from social and environmental aspects. Proper KPIs can be defined to establish this achievements and therefore to guarantee the long term sustainability.
Examples	The Linked Urban initiative states that MSPs are technologies, products or services that create value primarily by enabling direct interactions between two or more customers or participant groups. They enable direct interactions between two or more distinct sides, so the government, citizens and entrepreneurs retain control over the key terms of interaction. Each side is affiliated with the platform, so users from each side consciously make platform specific investments that are necessary in order for them to be able to interact with each other.

5 Other practical recommendations

Beyond the three groups of recommendations presented above, there are additional aspects that have to be considered by a smart city pilot.

First, IoT has an important role in Smart City activities, but it is not the only technological domain to be consider. There are various verticals in the city where IoT may be a clear enabling technologies, while others may rely on other technologies. As it has been already stated, problems in the city are often solved involving multiple domains. Therefore, a successful IoT Smart City pilot will typically comprise multiple domains, exploiting data from existing (sometimes legacy) systems in the city, where IoT can unlock additional context data to enable the required solution. Additionally, there will be IoT LSPs focused on specific verticals, making Smart Cities LSPs a good opportunity to demonstrate seamless integration among domains. Finally, the integrated view of the city can only be realised through a horizontal approach, which will also encourage the idea of viewing the “city as a platform” that will enable third party entrepreneurs to build services and solutions on top.

On a different matter, there are legal constraints that can hamper the feasibility of certain solutions or technologies in the pilot. Aspects such as data protection and how citizens will agree on how their data will be used, sharing or collaborative economy solutions especially in regulated sectors, driverless vehicles, usage of media from surveillance or other types of cameras, etc. are examples of this possible sources of impediments. The pilots are encouraged to test and push the legal boundaries, even if it is not clear at proposal stage how these issues will be tackled. From the AIOTI Smart Cities working group, and through collaboration with the Policy working group, these issues will be identified and highlighted so that legislative organisms can consider them and take actions.

Another relevant aspect to consider will be the digital transformation of the city. In order to track this dimension, it should be explained how the pilot will enable the (digital) transformation of cities, with KPIs which give measureable quantitative and qualitative progress factors, and how life in the city will be changed through the pilot (citizen's life, business life, workflows, processes, interactions within the city) and which benefits will be achieved.

Finally, since one of the major goals of these IoT pilots is the creation of a market for Smart City solutions by opening new paths and finding better ways of doing technology in the city, it will be important to show as part of the plan the goal of creating awareness of the problems, the solutions, the processes and the business aspects that will be considered essential as a result of the experience. Therefore, the pilots are expected to share their most important outcomes as assessment results and insights, relevant to the major challenges that could be expected for cities in the near future when dealing with IoT/Smart City real projects. Networks of cities as OASC can be a good vehicle to disseminate the results of the pilot.

6 Conclusions

In this document, a number of analyses, considerations and recommendations have been explained. These reflect the point of view of the IoT industry, but also the concerns of other relevant stakeholders, as municipalities, citizens and the local economies. The framework for these recommendations is defined in the Work Programme 2016-2017 of H2020, where the main goals and objectives are defined. Therefore, these recommendations are intended to provide clues for proposals and evaluators of how to create or select successful proposals based on the call description.

Smart cities are citizen-centred and the deployment of the IoT technological solutions developed by the IoT LSP will respond to the real needs of the people. The identification of people's needs is a key step in the ability to add value to the innovation process in order to accelerate the IoT deployment and exploit the results. Stakeholders should be identified and analysed in terms of their roles and specific interests, in order to determine what kind of products developed, created or assembled by IoT LSP could be of interest to them for deployment.

The IoT LSP need to exploit convergence to combine the different cities strengths in creative and technology industries to make the city-centric IoT technology ecosystem used to build a collaborative and innovative platform for professionals, and regular to innovate, co-create and distribute new content through the latest IoT technology developments.

Finally, the IoT LSP need to create a stakeholder Group of City Councils and public end users from the different European countries. Joint meetings need to be organised with City Councils citizens, and public authorities on issues that range from IoT technology and applications requirements/specifications, to interoperability standards, to appropriate timing for city-centric IoT technology ecosystem deployments.

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Annex I Current Smart City technologies

Technology levels	**Available technologies, architectures, standards**
Enabling hardware	Sensor types: • Light, noise, air quality, gas, temperature, humidity, traffic, optical, computer vision systems, energy consumption… Sensor standards: • SensorML, ISO/IEC 29182 Hardware interfaces: • RS-232, RS-485, I2C, SPI, IEEE 1451 Hardware architectures: • ARM, x86, PPC, MIPS
Enabling software	Smart City OS: • City OS, PlanIT UOS IoT/embedded OS: • Embedded Linux, Windows 10, Brillo, QNX, Contiki OS, RIOT, FreeRTOS, Tiny OS, OpenWRT, Java, C Smartphone OS: • Android, iOS, Windows Phone, Blackberry OS, Tizen
Enabling communication technologies	Wired: • Ethernet (IEEE 802.3), PLC Wireless unlicensed spectrum: • IEEE802.15.4, ZigBee, Wi-Fi (IEEE802.11), 6LoWPAN, LoRa, Weightless, IEEE802.22, Bluetooth variants (IEEE802.15.1), Z-Wave, DASH7, RF links, WiMAX (IEEE802.16), Sigfox, EN13757-4 Wireless licensed spectrum: • GSM, GPRS, UMTS, HSDPA, LTE High-level protocols and languages: • HTTP, Websockets, CoAP, Web services, MQTT, AMQP, JMS,STOMP, XMPP, UPnP

Platforms	Platforms: • FIWARE, Carriots, EPIC,SOFIA2, ASC, Cisco, Thingworx, Telit Standards used by platforms: • CKAN (Open Data), NGSI, ODBC IoT architectures: • IoT-A, IEEE, ITU-T, IoT World Forum, IERC
Services	Localization: • GPS, GALILEO, GLONASS HMI systems, dashboards Smartphone apps Cloud technologies SaaS, IaaS, PaaS, elastic computing, storage Service Oriented Architectures (SOA) Data analytics services Anomaly detection, trends, time series, Hadoop, Spark