CONNECTED CITY
Advisory Board

WIRELESS
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DRIVING NEXT WIRELESS EXPERIENCE

# Connected City Blueprint 2017/18


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# ABOUT THE WIRELESS BROADBAND ALLIANCE

Founded in 2003, the mission of the Wireless Broadband Alliance (WBA) is to accelerate global leadership for enabling of wireless services that are seamless, secure and interoperable. Building on our heritage of Next Generation Hotspot (NGH) and carrier Wi-Fi, the WBA will continue to drive and support the adoption of Next Generation Wireless services across the entire public Wi-Fi ecosystem, including IoT, Converged Services, Smart Cities, 5G, etc. Today, membership includes major fixed operators such as BT, Comcast and Charter Communications; seven of the top 10 mobile operator groups (by revenue) and leading technology companies such as Cisco, Microsoft, Huawei Technologies, Google and Intel.

The WBA Board includes AT&T, Boingo Wireless, BT, Cisco Systems, Comcast, Intel, KT Corporation, Liberty Global, NTT DOCOMO, Orange and Ruckus Wireless. For a complete list of current WBA members, please click here.

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## Executive Summary

This is release version 2 of the Wireless Broadband Alliance (WBA) Connect Cities Advisory Board's (CCAB) Connected City Blueprint 2017.

The paper builds on and expands on last year's Blueprint, looking at the issues that cities are encountering and overcoming to deploy Connected City technology to tackle their urban challenges. The Blueprint is intended to work as a guideline to support cities and government authorities to develop their connected city plans, and for the broader wireless industry, including academia, citizens, entrepreneurs, operators, regulators, equipment manufacturers and service developers to better understand the challenges and opportunities of the Connected City and Smart City ecosystem.

This year's paper is testament to the progression in the smart technology capability and the commitment of cities to use this technology to deliver benefits for their local communities. This paper highlights developments in smart capabilities and identifies lessons to be learnt from the most successful early adopters.

The continuing proliferation of data represents a huge opportunity for Cities. Those cities harnessing and exchanging data safely and securely have the potential to make enormous advancements in the fields of healthcare, energy, mobility, education and sustainability.

We are seeing rapid changes driven by the research and development of city trials which is creating new ways of addressing the way we manage our technology and resources.

The momentum of connected city trials is gaining traction, giving greater understanding of the issues and with this we are starting to see emerging trends. More integrated approaches to city issues that have seen a breakdown in some of the silo approaches to energy, housing, transport and health for example. Supporting the appearance of city platforms with more cohesive strategies and management of big data and IoT. Expanding the partner ecosystems to enable the delivery of the connected city vision. Uniting the gap between connected city programmes and city priorities

The structure of the Report is divided into three major parts:

Part I (Chapters 2 – 4): Identifying the importance of the Smart City Vision and the role of connectivity. What cities need to be thinking about to begin the process of developing a smarter and more connected City Ecosystem.

Part II (Chapters 5 – 9): The necessary technologies to help cities develop their Connected City Plan and identifying a set of case studies in terms of verticals implemented in cities around the world, acting as a benchmark for future deployments.

Part III (Chapters 10- 12): Examining the opportunities and services that can be explored by cities, including Big Data, Roaming and Public-Private Partnerships and an interview with the Deputy Secretary-General of International Telecommunications Union (ITU) with access to their in-depth research papers.

Throughout the paper, references are made to examples of deployments and processes implemented in different cities. This aims to bring realistic and real-world examples to the discussion in order to facilitate the understanding of the opportunities and challenges for the cities in the various aspects addressed in this report.

Overall, Smart Cities represent an evolutionary step in urban development, which is based on the combination of technologies and human resources with a common goal of achieving economic growth, sustainable development and optimal quality of life for the citizens. Connectivity in general plays a central role in the Smart City development, since they provide the means for interconnecting infrastructures (i.e. networks, sensors, devices)

and collaboration between the different stakeholders, including the Citizens, City Authorities, Private Sector Companies, Innovators and Entrepreneurs and the Academia, the key for success.

The CCAB and the WBA will continue the development of this Connected City Blueprint, both in terms of additional content as well as making it available to the industry in different channels, including an online eBook version. This is an Industry-collaborative effort and the CCAB would like to invite the different stakeholders to get involved in this initiative. The Connected City Blueprint can be considered a living document and updated versions will be released throughout 2018 and beyond.

# 1 Introduction

## 1.1 Background

While developing connectivity plans, cities have the responsibility to ensure that it is equitable, accessible, consumable and useful to the diverse constituent groups that cities represent. Cities must structure connectivity plans, their benefits and value propositions around a horizon that various stakeholders can understand.

Cities face several constraints (including land availability, population growth, revenues and resources) but must also look at ways to facilitate improvements in the citizens' and visitors' standard of living. Therefore, it is not just about technology, but also about the management framework supporting the connectivity technologies.

For cities that are just beginning to embark on their citywide connectivity deployments, the key challenges are based on understanding how to handle inevitable technology changes and the viable revenue models for public-private partnership. Even for cities that have done some deployments in the past, there is a need to validate technology roadmaps and business models.

The cities must cater to different scenarios – the backup plan for data versus managing security and high definition video streaming for police and transport, requires different capabilities. All these different use cases require different levels of connectivity. Therefore, cities need to figure out how all of this tie together.

It is also important to recognize that various cities are at the different ends of the development spectrum and there are differences in social, economic and political frameworks.

The Connected City Advisory Board (CCAB) was created to tackle the challenges previously described, and to develop, share and promote thought-leadership and practical framework for the social and economic development and sustainable operation of the Connected City Ecosystem.

It's a unique platform for city managers and CIOs to knowledge-share challenges and opportunities in the development and execution of the Smart City, establish best practices and determine a strategy to public-private partnerships.

The membership of the CCAB consists of a group of city CIOs and senior city and government officials along with industry experts and members of the Wireless Broadband Alliance (WBA).

The guiding principles of the group are to address and reduce the digital division and ensure digital equality through accessible and universal Internet connectivity, improve the quality of life of residents through hyper-connectivity and establish and grow Smart City's partnerships to increase shared knowledge and informed decision making.

Internet connectivity, at its core, is a civilization changer on the same level as roadways, water systems and electric grids. It is redefining the way people interact with the world, access and share information, and improving the way we live work and play.

It's a universal, global need that supersedes economic status, language and location. Having a global connectivity infrastructure provides the real potential to transform civilization forever

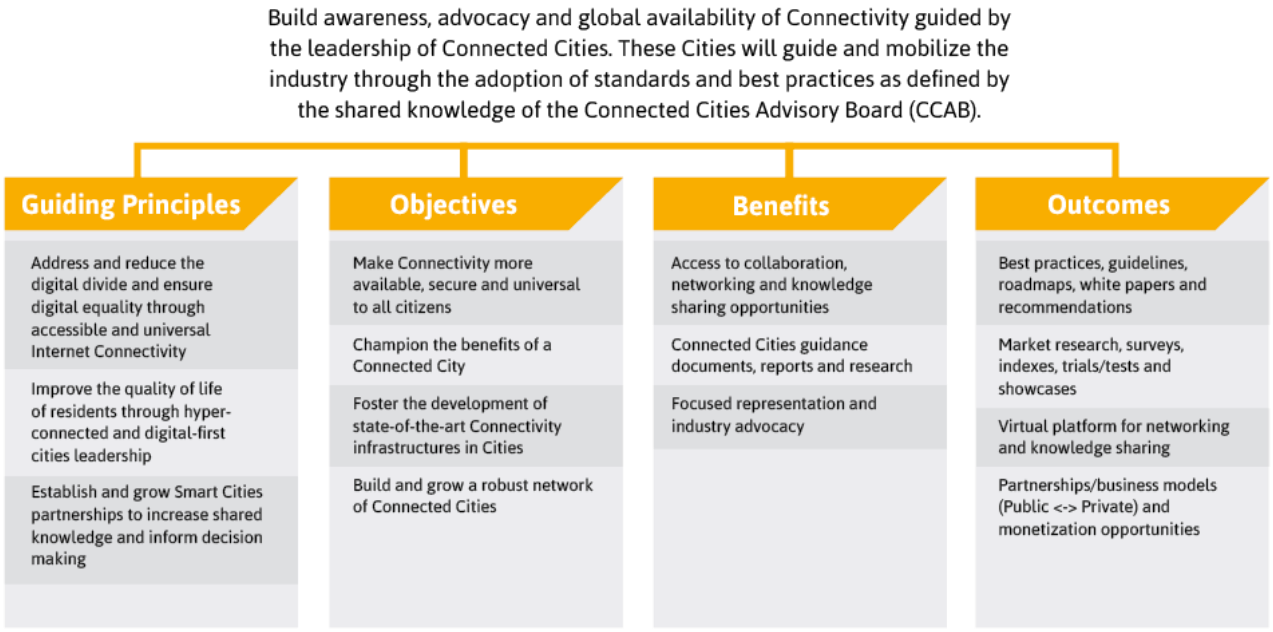



**Figure 1. Connected City Advisory Board Charter**

The Connected City Blueprint is intended to work as a guideline to support cities and government authorities to develop their connected city plans and for the broader wireless industry, including operators, regulators, equipment manufacturers and service developers to better understand the challenges and opportunities of the Connected City and Smart City ecosystem.

## 1.2 Smart City Definition

Smart City involves an ecosystem platform of multi-stakeholders and utilizes integrated information and communication technology systems, ICT, and data analytics, to transform its culture, structure, operations, economic development, and citizens' engagement to manage complexity and dynamically improve and enhance quality of life.

According to this definition Smart City is using technology to connect people, processes and assets in order to improve efficiencies for the cities, improve sustainability and improve the lives of citizens, businesses and city agencies, while creating a safer, more sustainable and civilized city for the citizens. The thread that's weaved through all of the solutions that adds this value is a secure scalable communications platform. It's all about improving the lives of the citizens, businesses and governments

to create a safer and more sustainable and efficient environment for them to live, to work and to operate.

The goal for any city municipality is to improve the quality of life for citizens and ensure that they are safe. This could be through new economic development opportunities, job creation, and/or making sure that they have the right infrastructure in place in order to leverage learning opportunities. Furthermore, from an economic development perspective, cities need to have the right infrastructure in place so that they can recruit companies which would add to the investment in the region and aid in job creation.

It's also important to promote start-ups and innovation in cities to leverage the Smart City technology and create open data platforms. This will also help to grow the innovation ecosystem and the start-up ecosystem that are currently in those cities. It is important to show clear differences between social/economical connectivity and technical connectivity.

In looking at the technical connectivity conception, International Telecommunications Union (ITU) defined a model that considers connections mainly in collection systems (transducers, sensors, actuators and communication networks), conceptual data warehouse and service applications for all normalized city devices and/or applications. There are standard interconnectivity interfaces for devices and/or applications from third parties who have interactions with cities. Consequently, we have connectivity or interconnectivity with devices, users and third parties at the network telecommunications level (i.e. Wi-Fi), data warehouse level (data or metadata) and at the application level (i.e. web services, open data, etc.), creating the concept and framework for the development of a smart city within all of these elements.

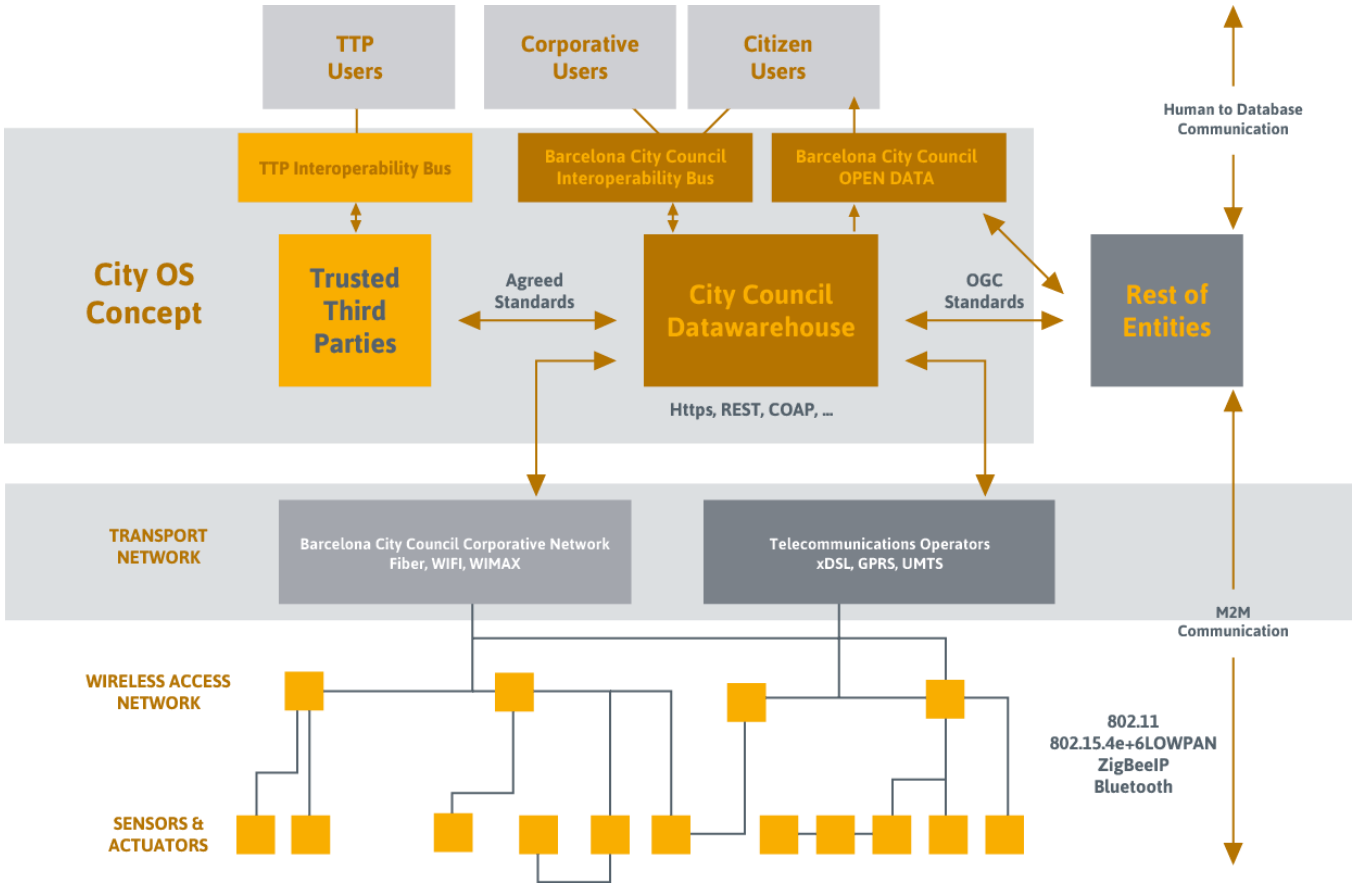



**Figure 2. ITU City Connectivity framework model**

## 1.3 The importance of the Smart City and its Challenges

Smart Cities are more than just the implementation of various technologies. "Smart" does not only refer to technology or sensors - it is a concept and new kind of culture in which cities and its agencies can work more effectively internally, with partner agencies and organizations and, of course, with their citizens.

"Smart" is a way of transforming from the way things have always been done because that's the way we did them, to thoughtfully considering what should be done based on analytics, metrics and adjusting the goals/mission of the city and various agencies based on that analysis, while continuing to update those goals as new and more relevant data is captured and analyzed.

Smart Cities are not a destination to arrive at, but a new process for managing how cities and agencies work.

Smart Cities can be a tool to positively affect policy changes at the municipal level in terms of everything a city does such as energy conservation, air quality/pollution, transportation, connectivity, data collection and sharing, etc.

- Smart Cities think about how their departments can better coordinate all of their activities and data.

- Smart Cities think about the data they collect and how to make it easily available to the general public to better understand it, to use that data in new and interesting ways such as apps, etc. allowing constituents to contribute to improved services.
- Smart Cities think about how to collect additional data that can be easily shared across departments to help each unit make smart, more cost-effective decisions.
- Smart Cities think of how technology and data can help them provide a better service to constituents, how they can make this service equally effective, but more importantly, cost effective.
- Smart Cities think about how constituents can contribute data and information to more quickly alert the municipality of problems such as malfunctioning lines, transportation issues, road work and construction, etc. Smart Cities can make an urban environment easier for people to navigate, live, work, play and to experience more out of the cities with various technologies than other cities. Examples include:
    - If a city understands more about vehicular traffic flow, they can better implement changes to the existing road infrastructure and right-of-way as well as parking issues. They can make decisions based on collected data that can change how cars are used in a city.
    - If a city understands how pedestrians and bicyclists move around the city, the data can be used to create newer and safer pathways for them to move around. They can combine that data with vehicular data to create a more cohesive system of movement within the city.
    - If a city knows when and where their public transportation buses and trains are at all times, they can significantly improve the quality of the experience for their constituents, reduce delays, and improve maintenance.
    - If a city knows how much trash is being generated, they can adjust their collection routes based on need versus routine, saving money, improving efficiency and freeing sanitations services to do more general cleaning to improve the overall cleanliness of the city.

The real benefits of a Smart City come from the data that is subsequently collected. At the start of the process, most cities won't fully grasp the benefits of pooling all of their data together; but by combining as much city data as possible, agencies will be able to answer questions that before seemed un-answerable. Additionally, they will begin transforming from a reactive city to a proactive city, and work towards predicting the issues affecting constituents before they become major problems. Such as:

- How are people moving around the city related to waste collection and does it depend on the mode of transportation that they are using? If more cars produce less waste, but more pollution, can those effects be analyzed?
- If constituents are empowered to report potholes, does that lead to quicker repairs and reduced bus transportation delays, making movement through the city faster and improving transit ridership?
- When different agencies share data, can they combine resources to get projects done faster and more cheaply? Can they more quickly complete construction projects because information is more easily accessible?

Smart Cities can be an extraordinary economic development tool. They can create their own transformation through a culture of collecting and sharing data within different government departments and agencies. This will undoubtedly affect how employees work, potentially creating new types of jobs related to the analysis of the new data forms and how to respond to this new information.

These are components of the culture shift that happens when cities become "smarter". Internal and field employees may need additional training to adjust to the new and emerging roles. New opportunities will become available as the new and valuable data flows through.

The smart nature of a city becomes a strong foundation for continually improving the collective intelligence of the organization, the ability to collect more specialized data based on what they have learnt, that they need, the type of experiments that they are willing to take, the coordination between agencies and the incorporation of participation and feedback from constituents.

But this concept of a Smart City is essentially a front-end concept - the back-end is also an extremely crucial component. This involves the network for communicating data back to the servers, how data is collected either by sensors or employees out in the field by using handheld devices, as well as how the data is stored and shared throughout city agencies and the public. This will be discussed later in this document. We will also cover several cases of Smart City pilot projects in this blueprint in order to help show how cities can take steps to become smarter themselves.

Right now most cities face many different obstacles that are slowing their ability to become Smarter:

- Infighting or lack of cooperation between government departments and agencies
- Fear of sharing data and potential security risks
- Inability to analyze any new data collected
- Insufficient funding for Smart City initiatives
- Cultural resistance throughout the city and various agencies

The concept of Smart Cities is very broad and different people will have different views; if you ask a dozen city officials what it means to be a 'smart city', you'll probably get 20 or 30 different answers, because people are still trying to figure out the intricacies of the term.

It is important to define a framework that would be the platform by which cities would become smarter. The identification of different programs in a city that have all been worked on and prioritized to help put a city on a path to becoming smarter. It's also important to note that the smart city concept is not necessarily new, with several cities around the world already offering excellent smart services.

Becoming smarter is about using the new wave of technology to become more responsive and more data-driven. Populations and constituencies need more and more services from their cities - they have higher and higher expectations of politicians and city officials, because they have built higher expectations in their everyday life with other service providers that they engage with.

City governments are now trying to find ways to live up to that expectation, in a world that also has more and more pressure on the resources that they have. Cities are just recognizing the opportunity to leverage technology to help solve these calls for a more responsive and in-tuned government for its constituency.

## 1.4 Connected City Ecosystem and Stakeholders

It is common throughout the world that City government departments and agencies work in silos, with a need to collaborate more internally. There is also a larger ecosystem that needs to be brought into the discussion. Cities must look outside their own ecosystem to develop and implement a path towards a smarter city. These stakeholders may include non-profit organizations that specialize in specific services such as homelessness, housing, education, etc., but also includes universities (particularly those with strong research departments) as well as larger companies based in their city and including start-ups who are innovating new smart city ideas. In addition, cities have the influence to bring in major utility (water, energy and telecommunications) providers as partners on their smart city path. For example, the electric utilities in a city may own 90 percent of the poles that lighting is attached. Partnering with them would make using a smart lighting system that much easier as well as the flexibility to attach other sensors to light poles.

By partnering with various utility partners, cities not only have more data available to them, but will also have the capability to combine these disparate data sets together to provide new insights and understandings of the needs of their constituents. Once that data has been aggregated, cities may want to do be more transparent and allow citizens access to the data so they can understand the value of having a smarter city.

**New York City:**

New York City has a much larger urban ecosystem than most cities across the USA and the globe. They view broadband in New York as a mission-critical utility service for the citizens of the five boroughs, much like electricity and water. The stakeholders in this ecosystem include: all types of businesses, government agencies, commercial entities, healthcare institutions, public safety providers, incumbent wireless agencies that already provide services to the City, and LTE incumbents who provide millimeter wave and fixed wireless services. Bringing universal, affordable, broadband services to the public at large is deeply embedded in the mission of the New York City government. The initiative in New York comes from the mayor and his unique approach to being able to proliferate broadband by making large capital investments. His goal is to bring universal broadband services to everyone, everywhere by 2025.

New York City approaches broadband proliferation by bringing together a host of city agencies, including the New York City Housing Authority, the New York City Economic Development Corporation, the Mayor's Office of Data Analytics, the Mayor's Office of Technology and Innovation and the Telecommunications Planning Unit of the New York City Department of Information Technology and Telecommunications. This last unit is deputized by the mayor to make real his vision of bridging the digital division in New York City.

Being able to create a truly connected city is the result of how the city governs its broadband proliferation and the quality with which it works with those stakeholders who have an influence on the

marketplace. In order to appropriately develop the broadband ecosystem in New York, they would have to put together a variety of different agencies who have, in the past, had independent telecommunication assets. They are now trying to take these independent assets, independent budgets, and independent acquisitions of telecommunications assets and pool them into one place so that they can better leverage what they have and figure out where they want to go. The city's initiative is to standardize and make their approach uniformed to deployment so that they can capitalize on what they have.

In New York they also have a broadband task force made up of citizens from a variety of different industry sectors, including the financial sector, public safety, waste management, etc.

There are no operators who might influence in a biased way the work of this broadband task force. Its mission is to take a hard look at how the city is approaching the proliferation of broadband and get input directly in terms of strategy, policy, and in terms of what they think might be the best fit.

Do we need more services in the subways? Do we need more services in our railways? Do we need to have more capacity at congested transportation corridors? Do we need more services in our job centers or in our homeless shelters? Or in other locations that are mission critical to the city? These are the kinds of questions the broadband task force addresses.

It's motivating and incentivizing to be able to do business with the city of New York, but to the extent that it’s not, they are putting a lot of franchise agreements on the surgery table today in order to lower the cost of doing business in under-served areas. They are also introducing methods that can be used to support incumbents and new entrants by allowing them to provision services from a surplus amount of fiber that they already have in the ground and extend it beyond their existing franchise agreement, which they may not have been able to do in the past. For example, some are restricted in providing services beyond the subway corridors. They have a surplus of fiber which New York City can allow to take out of the subways and go above ground in order to serve the railway passages, transportation corridors, schools, libraries, and other areas.

In New York City, local community boards are critical stakeholders in the telecommunications ecosystem. They consistently talk with the community boards about important localized neighborhood issues that come up around telecommunication services. NYC is installing Wi- Fi kiosks across the city, and every step of the planning is coordinated with political leaders, the borough presidents, and the community boards where citizens come out and talk about how they feel that their specific communities can benefit from the deployment.

At the end of the day, the proliferation of broadband exists for the public at large. New York City’s goal is to provide equitable, universal services. The idea is to proliferate broadband to help the community, schools, libraries, healthcare services, job searches, and even children with doing their homework.

# 2 Connected City Value Proposition

## 2.1 Importance of Connectivity to Cities

Connectivity is important to a city on many layers – for individuals, it means greater convenience and better quality of life; for businesses, connectivity helps to create new economic opportunities for

companies in all sectors such as tech, media, healthcare, logistics and more; and finally, connectivity also allows the Government to better manage and run the city by anticipating needs and providing improved services to its people.

Cities today are facing challenges arising from increasing urban density, aging population, healthcare needs, transport mobility, and energy sustainability. Cities around the world are experimenting with 'smart city' technologies to tackle such issues, and connectivity plays a key enabler role.

For example, in Singapore, public hospitals are currently trialing a tele-health rehabilitation system. With robust wireless connectivity, data is collected and transmitted from sensors attached to patients' limbs as they carry out therapy sessions within the comfort of their homes. This eliminates the need for patients to travel and wait for their appointments in hospitals. At the same time, the approach frees up Singapore's pool of therapists to render more dedicated care to a larger group of patients.

Connectivity powering big data and analytics technologies, and next-generation sensor networks help country's leaders to develop insights and share data more effectively, to improve operations and policies and build services to make life for residents better.

In Granada, Spain, the City Council has implemented an urban laboratory initiative to digitize Smart Waste Management Solution. It is a pioneering application of data analysis of municipal services. The project focuses on increasing the efficiency of municipal waste collection by using urban data. Fill data collected by sensors, together with urban information related to weather, traffic and special events, are sent to the data analysis platform. Using analytical models and algorithms, each day the platform generates optimal waste collection routes for emptying the selected bins.

The result is a new approach to managing waste collection services based on data and dynamic decision-making adapted to the needs of the city. The laboratory's goals include enhancing living standards in the city by reducing pollution and noise, since fewer waste collection vehicles are required; improving connectivity and the availability of information about the city; and enhancing operational efficiency.

By digitizing the government process, it's not just about adding conveniences to people, businesses and government officials who have smart devices and conveniences already. This will certainly be an outcome and it's a worthwhile one. However, the greater benefit is making government services more readily available to people who have less flexibility and less convenience available to them. One of the primary tools for making this happen is expanding connectivity for all areas of a city and for all members of it.

Developing connectivity throughout a city varies from city to city. Many of them do include determining how to best use city-owned real estate assets for the deployment of telecommunications service. One of the most important questions in Connected City planning is to determine whether a particular city wants to manage its destiny and the time to market for broadband proliferation by utilizing its governance system and its real estate. An example of this is the approach that New York City is using.

Using this method allows cities to broker relationships with third-party operators, whether by cellular, Wi-Fi, or otherwise. Telecommunications Planning uses the city's real property assets to support the growth of not only those incumbents, but all of those new entrants that are looking to provide services.

Whether it's trenching new conduit to provision fiber across the city or whether it's locating fifty to five hundred to thousands of new small cells on buildings, street light poles, other types of city street furniture, such as kiosks, park benches, bus stops, etc., it is critical to determine where broadband needs to grow equitably across the city. This is the importance of the Connected City plan.

One of the things that cities have to decide is: who is going to manage the operations of these networks? Does the city have an interest in investing and managing networks itself?

If a city decides to become a network operator/communication site manager/lead agency for all telecommunications operations, then it is going to go through a massive culture shift. The interest of the government in terms of proliferating broadband is much different than that of a third-party consultant. The consultant's interests may have higher margins or they may have an ability to oversee technical operations. However, they don't have the leverage that a City government has, subject to the use of infrastructure or the interest in proliferating broadband into mission critical locations. Nor does a third-party consultant typically care about equity.

Creating a lead agency for all communication operations is very important, it can then lead the leveraging of all telecommunication services to all city agencies and the use of all real estate in that city. The city now becomes a very powerful broker subject to bringing in telecommunications services. To an extent, it owns some of these assets, whether its fiber optic or common antenna across the city resulting in it being in a great leverage position.

Looking again at the example of New York, their plan is to proliferate broadband to everyone, everywhere, by 2025. By doing this in a way that is universal and equitable, they hope to be able to close their digital division. They have chosen some small-scale pilots to begin with by investing in the proliferation of Wi-Fi services in public housing authority complexes, where they can directly target who don't have connectivity digital division. They anticipate being able to take those lessons learned and scale that across the entire city.

Connectivity is important to cities because, in many ways, municipal government functions like a large conglomerate. Cities provide community services, utilities, public safety, engineering, human resources, finance, technology, regulatory functions and many other services. Much of what a lead agency in telecommunications does revolves around how they communicate and collaborate— and this means having an open dialogue with elected representatives and constituents, staffs operating an expansive infrastructure, and ultimately making the machinery behind our municipal services run.

Cities now have a new view on how to support that infrastructure that's more holistic for the same reasons. They see how things are connected and how rendering exceptional municipal services requires a new level of communication.  When they talk about the benefits of connectivity for cities today and in the future, the reality is that we're at a leap phase of what we call "smart cities;" meaning, using technologies to transform how governments run. Rather than just rendering a good singular municipal service, coordinated municipal services are more effective at helping our families and businesses to thrive. The modern organization that runs in an optimized way can communicate across its infrastructure and staff and measure its achievement in the success of the community.

This means that Cities have an opportunity to use this new constellation of connected and networked processing—with analytics on top of that—to improve what to do in insightful ways. This includes

everything from the safety of the city, to being more inclusive and friendlier to interact with citizens and businesses than cities have ever been. Cities are going to be more sustainable because of how they manage things and how they can see across municipal functions.

Some specific examples include dynamic traffic, predictive policing, water management, waste water and other utility systems, there various examples of these type of uses cases throughout this paper.

Family services. We can now render help to produce the best results for families. Never before in the history of local governments have cities had this many tools that potentially can work together for greater outcomes.

In the 21st century, connectivity is one of the essential pieces of infrastructure that a city needs in order to be economically competitive and a good place for people to live in. Connectivity underlies so many of the things that are needed for modern society. It can be examined in a few different ways: from a city's perspective, the city government itself requires connectivity increasingly in order to be able to achieve the operational goals that it sets for itself, like managing fleets, managing the built environment, smarter traffic flow, and better provision of public services. It has a role to play in that.

For the residents of the city that connectivity is something that is equally, if not more important, than that of the landline phone was in the previous century. A city that doesn't have a reliable, affordable, and high-speed connectivity available throughout its infrastructure is going to fail to provide opportunities to citizens they need to succeed.

In addition to those categories of the city itself and the residents, businesses are a key driver of the need for connectivity. In New York City, for example, it can be a challenge if a business is looking at renting space that looks like a good place to headquarter their business, but then they realize that there is not a good variety of choices of connectivity at that address, in terms of pricing, reliability, redundancy of speed, etc. This can be seen by commercial tenants as a major driver of whether a building or a neighborhood is attractive to locate.

It's getting more difficult for the city itself to have the capabilities to manage their telecommunications infrastructure. It can be challenging to compete with the private sector in terms of the salaries and job opportunities. Making sure that a city has the talent internally to be able to not only develop great systems, but also to be able to manage and maintain them is something that should be a priority for cities.

## 2.2 Smart Cities role on the economic and social development

There are lots of opportunities in cities and many programs being developed around the role of smart cities to accelerate economic and social development. For years, the ‘catchphrase’ has been “bridging the digital divide”, based on smart cities and broadband proliferation.

It is important to make sure that cities are addressing the connectivity need from the inner city and the urban setting all the way to the rural areas of the municipality. There's sufficient fiber available and a great opportunity to leverage the 5G vision and incorporate the right programs, such as tablets, for underserved or under privileged communities.

Smart Cities have their main role in economic and social development using PPP (Public Private Partnership) as a tool to collaborate between stakeholders and this topic will be address in more detail in section 10.

Looking into the specific example of the city of Barcelona the figure below shows this concept applied to a set of services. The starting point will be the city requirements or conclusions from research centers or RFI Processes. It usually starts with someone (often a startup) proposing a project. This project evolves into a pilot with the city supporting it. If the pilot is successful, the project can be expanded to a larger area or constituency and if that is successful the city has created a new normal that inspires and creates new pilots in other areas or services.

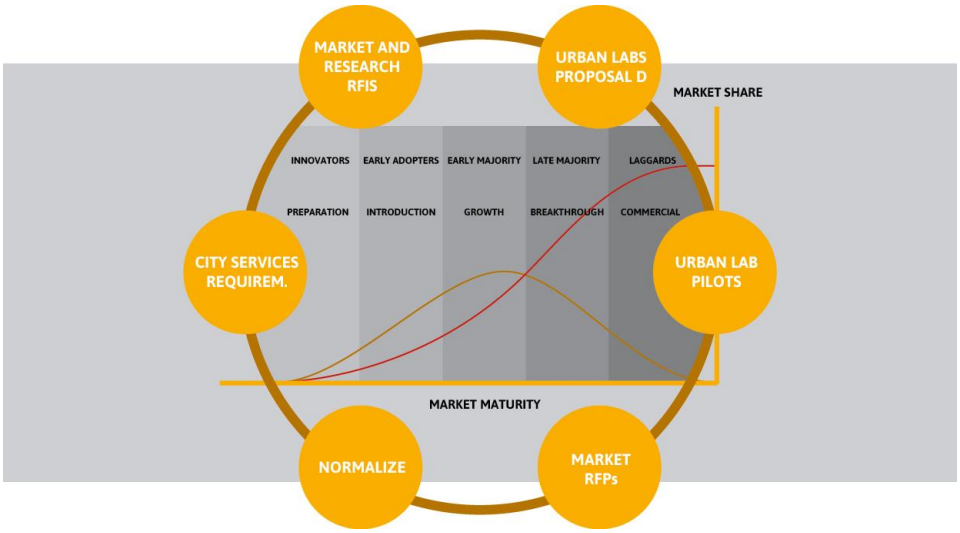



**Figure 3. Barcelona Urban Labs**

How Urban Labs Proposals work:

Once the proposal is accepted, the municipality assigns a project manager from the municipality, who will:

1) Study and agree the feasibility of the proposed project.
2) Facilitate the access to the infrastructure
3) Negotiate with local contractor's installation and maintenance of equipment for the proposed living lab.
4) Participate in results analysis

- Costs associated with the project (management, installation and maintenance) are not covered by the municipality.
- However, if the project has interest for the municipality the city can provide sources of funding programs in order to collaborate on grants/proposals with proposal entity.

Benefits:

- Involvement of city-knowledge in the development of new products and research actions.

- Possibility of generating patents on state-of-the-art products already tested in a city.
- Creation of economic activity based on these actions

This example shows how cities can mobilize their citizens and entrepreneurs to accelerate innovation, economic growth and social inclusion by generating more employment and attracting more businesses.

# 3 Collaboration, Government, Industry, Academia and Citizens

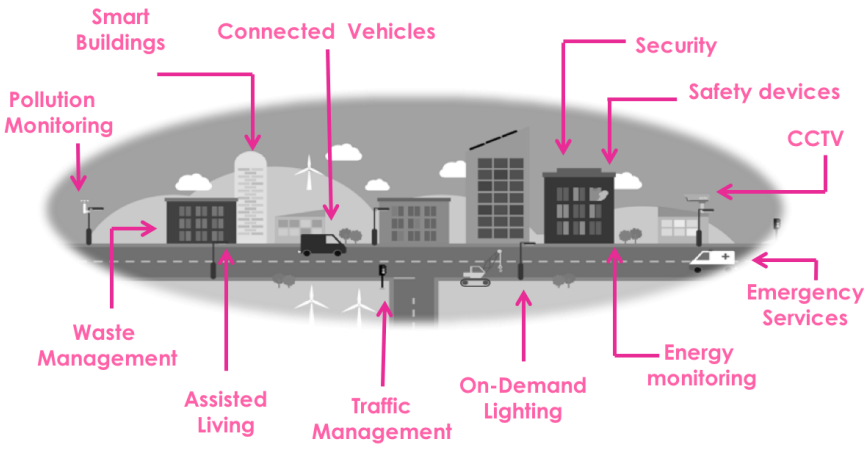
The figure below summarizes the major assets for each contributing sector in a city.

| CITIZENS | CITY AUTHORITIES | PRIVATE SECTOR | INNOVATORS | ACADEMIA |
|---|---|---|---|---|
| Create more participatory citizenry, where citizens are empowered to share and participate in governance and reshaping city life | Address innovative socio-technical and socio-economic aspects of growth by formulating proper policies and strategies to assist in planning initiatives and projects | Partner with the private sector to better deliver services to the citizens | Adopt and include technological, organizational and policy innovations | Partner with Academia sector to leverage on research to identify city trends and technological evolution |

**Table 3-1: Major assets for a proper governance in a city**

## 3.1 Collaboration Use Cases, Government, Industry and Academia

Government, Industry and Academia collaborations - driving Innovation to solve city problems to enable SME, commercial and citizen engagement.




A **SMART city** is an urban development vision to integrate information and communication technology (ICT) and Internet of things (IoT) technology in a secure fashion to manage a city's assets.

The data collected from the city's assets is then used as the means to improve or solve the city's economic, social and environmental challenges.

*A smart community may be one of any size or significance, geographically separate or part of some larger urban unit, that employs the IOT to:*

- *Improve aspects of its operations or other factors within or outside its boundaries that are important to its economic vitality, safety, environmental footprint, quality of life or other factors deemed significant;*
- *Respond to the community's changing needs rapidly and efficiently;*
- *Engage the community and enable informed understanding of, and where applicable consent to, what it is doing;*
- *Collaborate with other communities as needed or desired."*

**Dr. Peter Williams, CTO, Big Green Innovations, at IBM.**

Use Case example for Government, Industry and Academia collaborations - driving Innovation to solve city problems with LPWA IoT to enable SME, commercial and citizen engagement.

Two examples

1) MK SMART (Milton Keynes)
2) Things Connected

MK SMART was started in January 2014

**"MK SMART"**

MK Smart has been a long-term pilot which is now complete. Some elements of this Use Case pilot are now being rolled out on a larger scale with commercial partners and the Everynet network Infrastructure has now been donated to the "Things Connected" network to expand the coverage of that network.

**"Things Connected"**

This was an open innovation Everynet LoRaWAN IoT network deployment to cover London initiated and run by the UK Digital Catapult and BT. The network has now been extended in other cities and plans to roll out another 6 cities are underway and due to begin deployment in March 2018.

**"MK SMART"**

The scope of the use case was to determine if IoT LPWA networks could affect efficiencies in the city and influence consumer engagement and behaviour.

**"Things Connected"**

The Things Connected network is, an Innovation support programme targeting UK businesses who wish to leverage the capabilities of LPWAN technologies. Providing start-ups, small businesses and developers improved access to LPWAN networks.

**The Use Case objectives and goals of "MK SMART":-**

The entire MK SMART project focused on how to sustain the growth of MK using IoT

- Infrastructure challenges to 2026
- 28,000 new homes
- Population growth to 300,000+
- City Infrastructure will be under strain

**WATER CONSUMPTION TRIAL**

Can we bring different data sources together to change people's behaviour?

Combine data from soil moisture sensors with weather forecast to provide indicators that could forecast the needs to water gardens or not.

***Garden Monitor application***

- Provide water usage on an hour by hour basis through a smart metering trial to show users how much water they use
- Water Monitor website
- Test the effectiveness of influencing customer behaviour

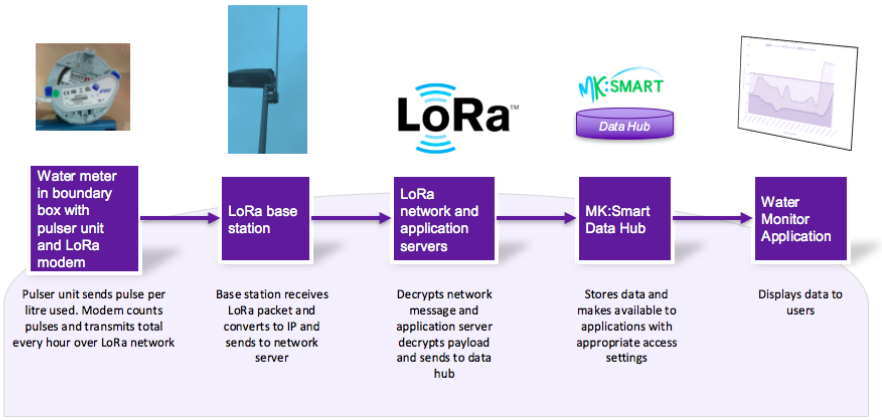



**Figure 4: MK SMART IoT City Architecture**

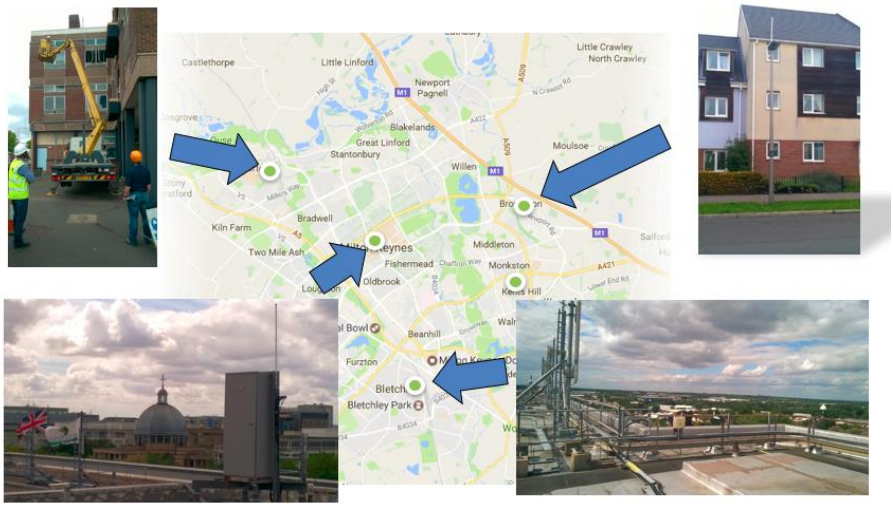



**Figure 5: Everynet LoRaWAN gateways in Milton Keynes**

Things Connected started in September 2016

Things Connected will foster the emergence of a strong UK based LPWAN ecosystem to ensure the UK is open and ready to innovate with the Internet of Things (IoT).

Things Connected will encourage the deployment of sensors, applications and services and to enable businesses to develop exciting and novel IoT products and services

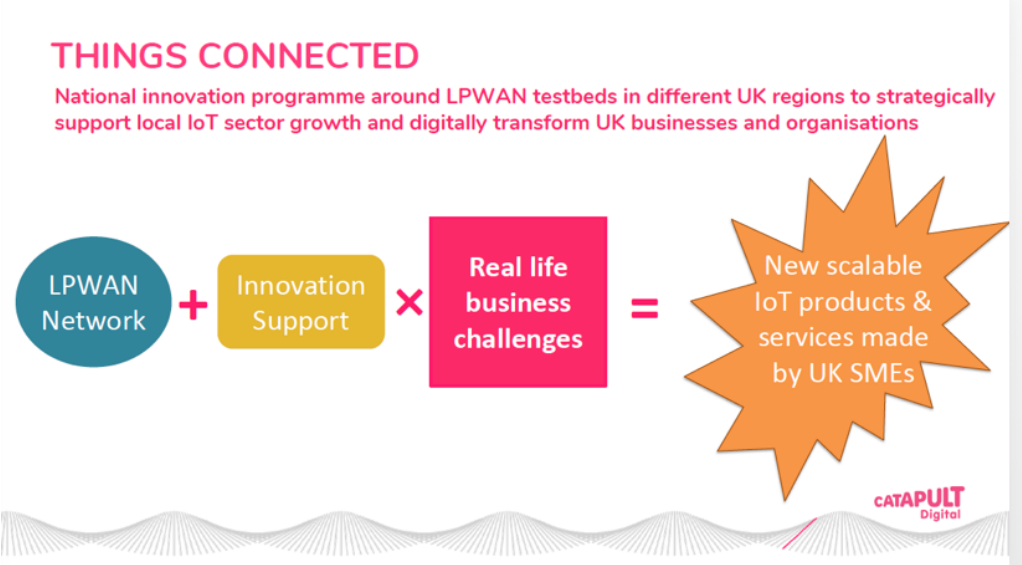



**Figure 6: Things Connected**

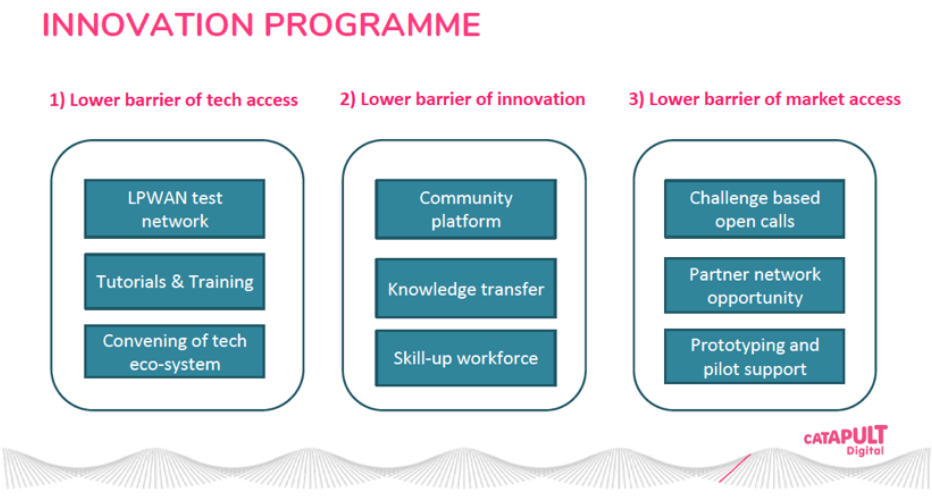



**Figure 7: Innovation Programme**

This was a collaboration of entities included in "MK SMART"

- BT – Service Provider and Project Owner
- Everynet Ltd – Technology and Network Platform Supplier
- Anglian Water – Utility Company and End User
- MK SMART – SMART City Consortium
- Open University - Data Hub provider and the collaboration for "Things Connected" included
- The Digital Catapult – Project Owner, Network Manager and Innovation facilitator.
- BT Partner, infrastructure provider and End User
- Everynet Ltd – Technology and Network Platform Supplier
- Technology partners for LoRaWAN modules and Application Enablement Platforms.

**The technologies in each project were: -**

**"MK SMART"**

TV White space, Weightless and finally LoRaWAN technologies were tested, Everynet LoRaWAN proved to be the only LPWA network technology that offered all of the requirements for success both technically and commercially.

**"Things Connected"**

The Digital Catapult has many different LPWA initiatives and is technology agnostic, however Things Connected is an Everynet LoRaWAN based network only and was defined as such from the start.

Both projects offered significant training and learning opportunities which was provided by the project teams.

***"MK SMART"***

The project was funded by the MK SMART Consortium and BT.

***"Things Connected"***

The project was funded by the Digital catapult and BT.

Both projects were defined by the lead organizations involved from the outset.

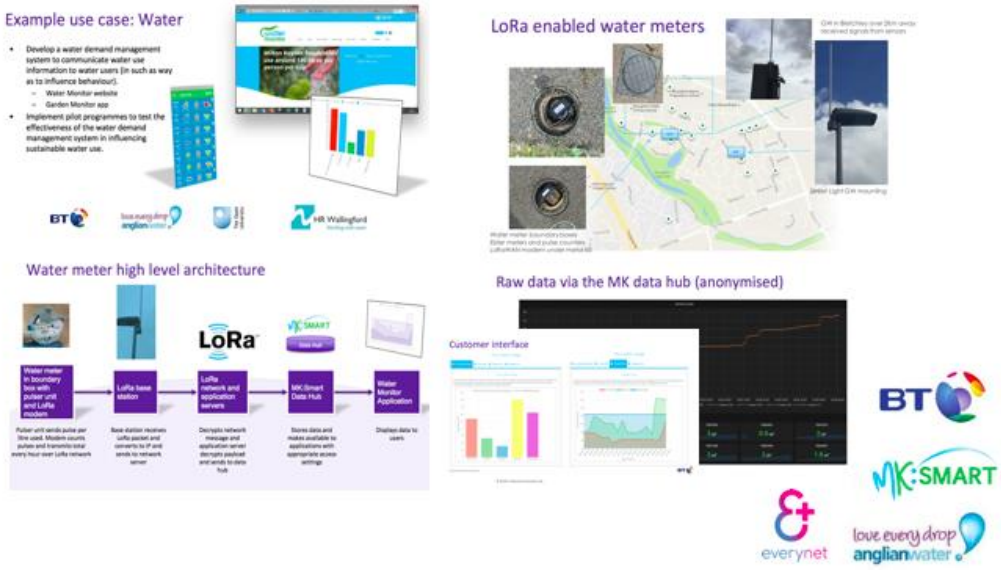



**Figure 8: The key benefits from the MK Smart and Things Connected Use Cases**

- The technology was proven both technically and commercially to be able to deliver efficiencies for the respective parties.
- Consumer engagement was obtained via the online portal when individual usage could be monitored and measured against other users and influence their water usage behaviour.

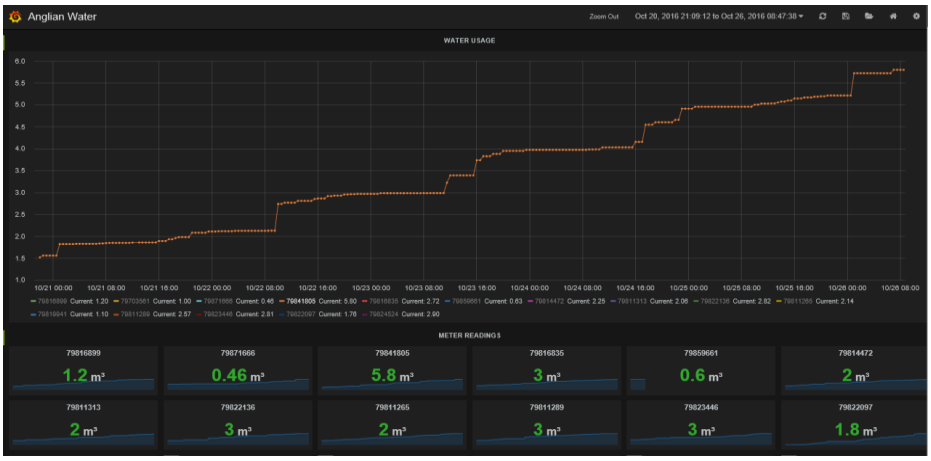



**Figure 9: An example of hourly consumption**

**Challenges encountered:**

***"MK SMART"***

The primary challenge was to ensure that scalability would be possible should the trial prove successful, real world, not demonstration devices were used and network infrastructure was deployed as a permanent installation. This was overcome by using carrier grade network technology and working with industry leading partners.

The trial provided evidence potential for wider benefits as city grows towards the pre-set goals: Limit the growth in water demand at 0% by 2026

***"Things Connected"***

The initial challenge was to get engagement from both citizens and businesses to use the network, "build it and they will come" is not that simple. Meetup groups, social media and open calls along with events to make the initiative visible and ensuring that connection was simple and safe to use was successful.

Multiple vender's collaboration working well

Both Projects used many partners each added value by bringing their own expertise, the projects demonstrated how collaboration enabled much larger objectives to be reached that would have been out of both scope or budget without collaboration.

**What are the future areas of improvement or development?**

***"MK SMART"***

- The water metering trial is being rolled out on a larger scale but is commercially sensitive,
- The network infrastructure has been donated to "Things Connected" to extend coverage of the network.

***"Things Connected"***

- Is expanding coverage beyond London in 2018 and has set up six new hubs for innovation and has open calls out to encourage participation solve problems for the Social Housing, the aging population and leading Industrial companies.

**How the results were evaluated:**

The results were evaluated based upon the original objectives, MK SMART Water Metering use case is being assessed as a potential commercially project as it delivered against the objectives, Things connected delivered the innovation community and real world products that will deliver sustainable businesses.

The major achievements of these Use Cases for the city and their citizens/visitors:-

- MK "top-down" approach to solve specific problems

- Gained experience of LoRa deployments within project team
- Business case led so solving real world problems
- Limited engagement with wider ecosystem partners in MK
- London "bottom up" to encourage innovation and use of the network
- Wider sharing of learning and knowledge

With the ending of the MK:Smart project, the LoRa gateways in MK are now part of same logical network as Things Connected London

- Opened up MK LoRa network to any user
- Data visible through Things Connected portal
- Feeding experience into new projects
- Cityverve in Manchester
- Belfast

***"MK SMART"***

The trial provided evidence of potentially for wider benefits as city grows towards the pre-set goals: Limit the growth in water demand at 0% by 2026 A larger commercial deployment is being planned for the water metering use case. Citizens were educated and engaged in their water consumption.

***"Things Connected"***

- Visibility, education and engagement on LPWA as a solution to city problems.
- Leading UK Innovation from the front with tangible SME's delivering new projects.
- Developing a forum for a community of SME's and Developers to explore LPWA benefits for the city.

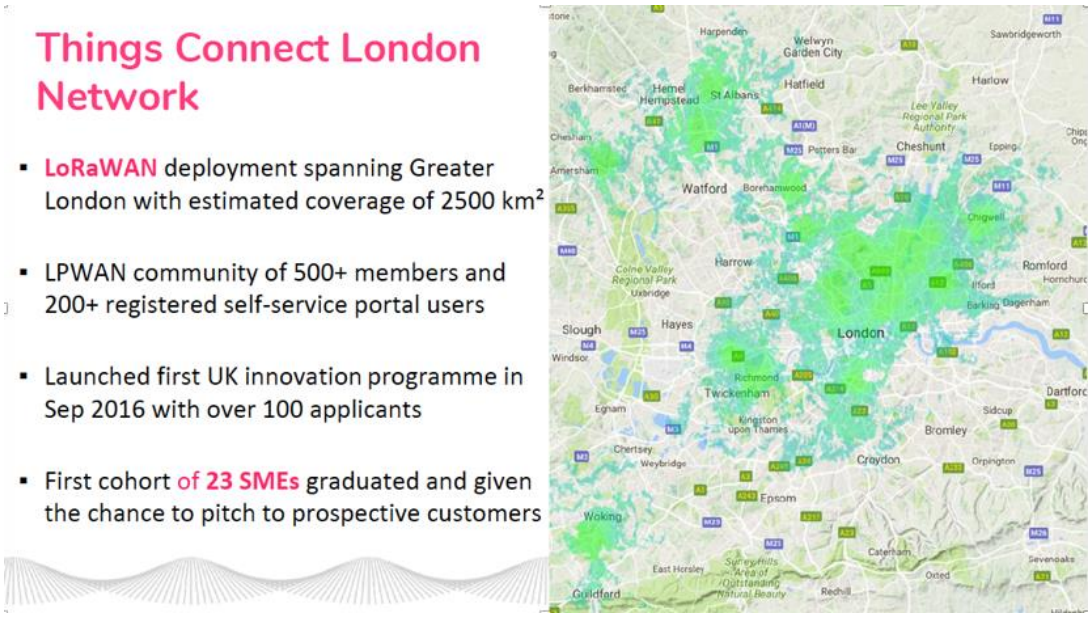



**Figure 10: Things Connected London Network**

"MK SMART" Citizen engagement was a key metric and this was achieved by education and a water usage portal.

"Things Connected" By making the network open to all, anyone could use it, including the general public, hobbyist developers as well as SME's and Academia.

In both project's the data collected gave insights into the specific use cases that were unexpected, both in the end results themselves illustrating that insight not data is the end goal. Additional Products were developed, supported and mentored in this environment and are now commercial products:

See Sense, Beringar Ltd and 8 power Ltd are just three examples of tenable products that were developed and tested there are many more.

**Key recommendations for other cities who decide to develop a similar use case?**

- Set your objectives, find some partners and just do it, don't talk just about it!
- Potential expansion plans / next steps for this pilot / projects.

***"MK SMART"***

- This project is now over but further commercial deployment on the water metering use case in being planned.
- The learning can be shared with other cities engaging in such collaborations: City Verve in Manchester and Belfast.
- The MK SMART network is now part of ""Things Connected"

***"Things Connected"***

- Is expanding coverage beyond London in 2018 and has set up six new hubs for innovation and has open calls out to encourage participation solve problems for the Social Housing, the aging population and leading Industrial companies.

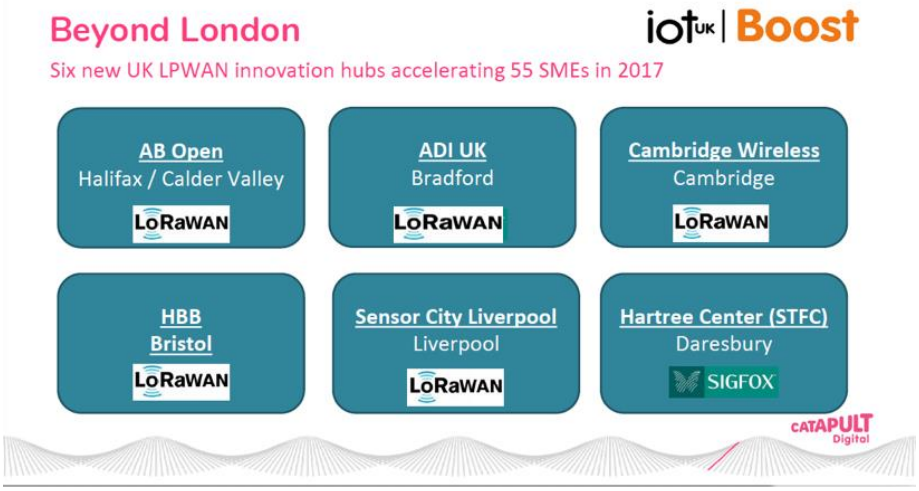



**Figure 11: Beyond London**

## 3.2 Citizens' Engagement

The goal for any city or municipality is to improve the quality of life for citizens and to make sure that they are living in a safe and sustainable environment. Across many cities and countries, there is growing evidence of collaborating with citizens to get them to participate and help shape this environment.

Some cities are making a more concerted effort to increase citizen engagement, whether by directly soliciting their input or by collecting additional data about the habits and needs of constituents. To do this effectively, cities need to have a clear idea of what their own goals are and what they are trying to achieve. One of the core promises of big data and connected cities is to have an increased understanding of your constituency in order to better understand their needs, while simultaneously effectively soliciting their input and ideas. This engagement will also help citizens understand the potential benefits of smart cities and all smart city efforts, which can lead to support of investment and increased participation.

This is a challenge for fast moving, nimble companies that are motivated by increasing efficiency and customer satisfaction to make more money. However, it can be even more difficult for cities and is a break from the way many people perceive government. While encouraging input from citizens it is also important to understand the difference between what they are asking for and what they really need.

Citizen engagement generally happens in one of two primary ways: passive engagement and active engagement. The passive feedback loop is becoming stronger with the development of Internet of Things (IoT) and smart cities. Cities now have the ability to put sensors on streets or have other smart systems. Cities could have other smart systems that are paying attention to how people interact with their

municipality services, so cities could be generating feedback from customers in a passive format, just by the nature of them walking up and down the sidewalk. If cities collect footfall patterns or traffic patterns, then they can take that information and consider adjusting the way cities are designed, particularly things like bike paths or pedestrian walkways, without any direct action from customers, other than them just going about their business. This passive feedback loop is what has become very interesting and much more informative, in this new era, just because cities have the ability to collect data in these different ways.

| | |
|---|---|
| **Active Engagement** | Public meetings that people can come to, where they can voice their opinions or their desires or requests or grievances in an open forum. That's an official gateway to receiving that kind of feedback. |
| **Passive Loop Engagement** | Maybe less formal but similarly traditional and intentional active methods. Use citizens' indirect information in order to understand what they're asking for services and then aggregate those into information |
| **Passive Engagement** | Citizens only interact with cities authorities if they are somehow pushed to do that, either throw surveys or voting processes for a specific decision |

**Table 3-2: Types of engagement with Citizens**

**Milton Keynes are supporting their citizens to shape the future of their Smart City**.

Smart City projects are often solely focused on technological solutions. MK listens too and acts on what MK citizens think would make our city more sustainable.

The Citizen Innovation team is made up of researchers from The Open University, community outreach experts from **Community Action: MK** and designers. Together they are developing a new understanding of how to facilitate citizen-led innovations that make local communities more sustainable. Smart City projects too often focus solely on technological solutions to address urban sustainability issues while ignoring the existing community and grass-roots initiatives. As part of the MK:Smart initiative, they have developed two different approaches for harnessing the collective intelligence of local citizens to co-create a sustainable future for Milton Keynes.

The first approach saw Community Action: MK's Community Mobilisers go out into communities to talk to people about their issues, interests and ideas and record impacts of interventions and activities, as part of an engagement programme. They then analysed these conversations to generate an understanding of city-wide priorities. They have been using an engagement app called QuickChat to collect dialogue from people across the city. The app was developed by Graymatter for Community Action: MK and since its creation in 2013 over 20,000 pieces of dialogue have been collected. Over 900 of these have been 'smart' conversations with people across the city, and they have heard all kinds of ideas from text alerts if your bus is running late, to a school workshop to teach kids about their energy and water use. The second platform was an online ideation platform, **Our MK**. The Citizen Innovation work package has supported people to play an active role in urban innovation, from the crowdsourcing of initial ideas through to funding and supporting citizen led projects. They have seen Citizen's projects come to life through the Our MK process.

View The MK:Smart Video

## 3.3 Clear Leadership. The Role of the CIO

What is the present role of a CIO in a city's development?

Cities regularly face several challenges and opportunities, which is one reason why we are seeing more and more cities with more typically corporate roles such as Chief Information Officer, Chief Technology Officer, Chief Innovation Officer, Chief Digital Officer, Chief Infrastructure Officer, Chief Marketing Officer, and/or Chief Customer Officer. These new roles in government are focusing more on understanding, communicating with and working across the silos of departments and organizational lines than it has in the past. As discussed earlier in this blueprint, smart cities are more about changing a culture. If this new Chief role isn't given the proper authority and oversight to reach across all departments and agencies, the chances of success are limited.

Where CIOs and CTOs can really help is by giving government workers in all agencies a better understanding of how all of their work connects together. They can see where departments are duplicating efforts or providing similar services or using technologies and applications that don't work

well together and much more. The key for them is to show the various agencies the potential of combining their resources, their technology and their data together to create something that is bigger and more effective than they can be on their own.

The CCAB architecture allows city leaders to say, "Here's how I perceive and approach the problem" in a way that's consistent with others. Cities can have a community of practice, a common dialogue and vernacular, an understanding, and shared insights. There's amazing value in what CIOs, CTOs and other CXO's can do together by rising to the challenge.

The goal of these new Chiefs should be to not just think about technology, but how collaboration can improve services, but also create new innovations the city has never before been able to provide.

# 4 Develop Effective City Plans

## 4.1 City planning

City planning is one of the main reason behind establishing the CCAB and the development of Smart Cities. Many cities are working on developing effective plans and there's a lot of qualified, competent energetic people in different areas in different cities. Each city is planning from its own perspective and the value is to broaden that perspective. To be more specific, there are some cities that are focused on specific applications of the Smart City, but a city with a smart lighting project is not a smart city - it's just a city with a smart lighting project.

A city that has a smart lighting project and is investing in the framework to accelerate smarter infrastructure projects, is a city on the path of becoming smarter. There are cities that have, for whatever reason, their local politics or their local needs, focused in certain areas. Some cities have been thinking for a long time about the Internet of Things (IoT) There are some cities that have really been focused on the data programs. There are other cities that have really focused on connectivity. All of these things are the core elements.

Bringing these cities together can build a more robust planning framework. The essence of a smart city is a city who has a plan that is comprehensive. Even if they are not yet investing in particular areas, but that their plan recognizes that all of those areas are important. One city may be putting a lot of money into connectivity, but it may not be focused on data yet. If their smart city plan acknowledges the need for data, then I think that city is better poised to execute.

The framework that we're working on in CCAB will help develop a structure for cities that are developing their smart city plans. Cities are in a very early stage with this type of technology and are still at the very beginning of this conversation on a global level. Many are still at a point where they're trying to construct what the plan elements should be and then putting a plan together.

Some cities are further ahead than others. For example, Singapore and Dubai are two places doing fantastic work in this area.

The CCAB is creating a platform to learn from them and other smart cities/nations to accelerate the smart city planning and implementation process to allow cities to increase the pace and outcomes and

cut costs associated with their smart city projects and planning. This is the value of sharing best practices and lesson learned, because our problems are common and similar, even across geographies.

When it comes to planning a "Smart City", it becomes clear how multidisciplinary a connected community and a smart city can become. Cities are running into the barriers of functional silos and learning how they need to work better together.

As an example, let's consider the typical process of building a house; the different trades work very independently. Plumbers, foundation layers, framers, etc., each do their various tasks without communicating with each other. That used to be how cities often functioned. Public Works only thought of IT staff for PC support and the police rarely talked with Engineers. In contrast, many cities are now requiring agencies to coordinate more every day. Cooperation and collaboration between agencies are vital to the success of every major city.

Cities must work differently for better planning changes with the size of each city. In terms of the scope, when large cities implement a smart city plan at a large scale, there are more exceptions and variables than in a smaller city: housing clusters in communities, types of topology, streets and traffic design, codes and comprehensive plans, and age of infrastructure. You might have newer infrastructure in one place, and older ones in another. It's more likely that you have the central government bodies, state, counties, and other cities to work with, as well.

In terms of how you plan Smart Cities, larger cities have a larger portfolio of things that could go wrong, these need to be carefully worked through. However, success is still rooted in having a superior vision, with all of the best minds working towards a shared outcome, an understanding of newer technologies and methods, developing good vendor relationships, and piloting things to test concepts.

How do you make the city deal with the planning, in a more holistic manner, rather than the silo approach that has happened in the past? What we have seen from small cities to medium sized cities to large cities and at the state level, is that the ones that are going to be successful are the ones that are collaborative. Communities that lead have executive clarity that there are no fiefdoms, that all will work together towards a clear outcome. Otherwise, cities will not be able to solve the problems.

Looking into the example of San Jose in the US, they improved themselves when working on the Facebook project for their Terragraph technology in downtown, and they worked with Silver Springs Networks to put IoT in the city. They also worked with the Eastside Union High School District to bring underserved/disadvantaged students into the fold of a connected community through faster internet connections. These projects are mentioned because it expands what cities have to offer: the way it permits, the way it partners, and the services a city should offer.

Another good example are light poles. It's clear that cities will have to manage those pole attachments differently in that there's limited space and power. Cities will also need to be strategic in what they connect to the network; whether or not it wants to be an ISP; how to manage support and service requests; and how it will contract. All these things that really help you get a clearer vision of what the problems are, once you understand what the vision is based on the outcome that you want. The mark of a great organization is that they are a demonstration organization. They pilot things. Their staff prove things and learn from their experiences. Then, they can build what others cannot because they have learned more effectively.

It is about who solves more problems rather than who owns what.

For better planning, there is a need for things that push us to be a different organization on the other end of that pipeline, and how people work together with that. Where executives are involved, and city managers and councils, where they can push the limit to say, "We're weighing how you get to the other side of the vision. We don't really care who owns what."

This then raises other questions that come out of this scenario, especially in the USA; for instance, based on transportation, you have to coordinate with the federal government and say, "We need you to broaden how those usage policies are for the federally funded fiber networks that are out there to safeguard the transportation usage, but with that extra capacity allowing other uses. Wireless frequency should have public uses reserved and they get how it is prioritized."

In the New York City example, they have the Department of Design and Construction and have the Department of City Planning and the Economic Development Corporation, and the Mayor's Office and its broadband expert. All must understand together where the city's growth is going economically, where the city is planning to build new affordable housing and new transportation corridors, such as bus routes, shipping lanes, and ferry crossings. City economic and civic growth has an impact on how you size, scale, deploy, order, and prioritize where your broadband will grow.

You have to have a collaboration with other agencies in order to make sense of the telecommunications growth in your city.

It is a challenge in big cities to get this kind of collaboration; to agree on what the telecommunications growth should look like and where it should take place. Sometimes, because the streets are being opened for one reason in a neighborhood, it also makes sense to lay down fiber there at the same time. Cities need to have an equitably-based, comprehensive plan.

Once cities have a plan, they can get to more schools, libraries, and multiple dwelling units. They need to be able to get to housing authority locations or lower-income neighborhoods that would be devoid of having this broadband path.

The Economic Development Corporation's knowledge and foresight subject to how the city is economically growing based on demographics, traffic patterns, and where current broadband already exists and where it does not, leads to quite a few decisions in terms of what is going to make the greatest impact.

City Planning also contributes, in terms of knowing where new commercial and new transportation corridors will be built and/or modified over time, recognizing activities that are going on in New York City, much as many cities around the world. They look at these to determine whether or not to replace or modify street light poles, for example; While removing and repaving streets, why not build new infrastructure like more street light poles that can accommodate both Wi-Fi as well as 4G and 5G deployments?

The sheer size of New York City means they cannot tackle everything at one time. There are a variety of small pilot projects that they are working on and once they are proven successful, they will proliferate those across the city in a broad way. For example, NYC is bringing affordable public Wi-Fi to the city's

housing projects, but the City's Housing Authority covers thousands of residences. So, they are starting with five projects, one in each borough, and then they will branch out from there.

By the same token, they are modifying small areas as they rezone them, like East New York, to invest in creating the city's own conduit while the streets are open. In both of these instances, NYC is able to provide fiber services to a variety of new commercial and residential neighborhoods that were traditionally devoid of broadband.

New York City is developing the connected city by going from the heart of Manhattan all the way out to the outer boroughs. They have the core fiber hubs in the urban area. In order to reach the outer boroughs or the outer perimeters of our marketplace, they really have to start from the core and then grow out.

They are also taking a look at areas outside of Manhattan—what they call the Outer Boroughs of Brooklyn, Queens, the Bronx, and Staten Island. These places may not have fiber infrastructure in the ground. Trying to determine whether the city would like to connect them through millimeter wave fiber backhaul solutions that could then be used as hub locations to provide wireless, high speed services much faster and at a lower cost than provisioning fiber all the way out to these locations.

The New York City broadband initiative is continuing to grow. They continue to attract new talent and new leadership that brings new ideas to the table, new creativity and new innovation. This cycle of generating revenue from the city's own real estate will make it possible to finance more and better broadband ideas and their plan is for New York City to continue to lead in innovating telecommunications services.

## 4.2 Broadband Planning – Universal Best Practices for Municipal Deployment

Broadband Planning – Universal Best Practices for Municipal Deployment- Connected City Advisory Board for Connected City Blueprint

**Background**

The global telecommunications and broadband planning industry is experiencing an evolution in implementation for next generation mobile and fixed wireless and wireline operations. In the past, acquiring municipal real property assets for fixed telecommunications equipment was incumbent upon each provider, predominated by the major cellular carriers, public safety entities (federal, state, provincial and local), cable and fiber operators to recon, field caravan, select site candidates and acquire through long term leasing documents as many viable municipal sites as possible under hopeful master lease/license agreements. With many new technologies on the horizon, i.e., IoT devices, 5G small cells, national public safety sites, mmWave devices, etc., acquiring viable telecommunication sites which could contribute to a rapid time to market and low costs are becoming increasingly more difficult to obtain. The sheer volume required by each carrier and with no particular streamlined policies, nor procedures, from most government agencies will result in the new technology deployments being delayed.

## 4.3 Existing Good Practice examples

Outlined below are some of the best broadband planning and deployment practices and policies collected from a variety of City Planners and Mobile Operators on the drawing boards today in urban and suburban markets globally.

## 4.4 Municipal Governance.

It is essential that municipal Executives charter a mandate to build, direct, fund, deploy and operate broadband networks in their respective marketplaces. The Chief Executive/ City Leader of any Municipal Government must decide as to when, where, how, why, funding, sustainability, resilience, technology and the overall governance and management of the network to be built. The Chief Executive / City Leader must also decide if the network is to be built by the municipality, through private public partnerships or completely outsourced to third party operators. Other critical decisions on building municipal broadband networks must also be considered prior to such prospective networks being funded such as; cybersecurity, data management and privacy policies.

The Chief Executive / City Leader must mandate that all Government or City Agencies cooperate in the standardization and uniformity of centrally managing, accessing and acquiring real property assets to facilitate telecommunications buildouts. It is important to raise this issue above temporary political influences that could impact / dictate the network deployment of a cities broadband or telecommunications network rendering it potentially unsustainable. As important as the centralized management of real property assets is, the centralized management of existing fiber, wireless and equipment assets is critical. Efficiencies of scale, efficient network utilization, and resiliency can only be met when the assets of all agencies and departments are managed as one network by one organization. There are many instances where local government, federal, state, provincial and or municipal political electives have influenced the quality of service (or lack thereof), performance, service area footprint, etc., opposed to allowing sensible and practical design, planning, operations and engineering solutions set the strategies for the deployment plans of urban and suburban markets.

It is much better to craft your markets telecommunications plans starting with a smart, sustainable, affordable, ubiquitous and resilient business plan and then draft mature, flexible and future proof policies surrounding this business plan before handing off to the Political Executives to announce publicly – as opposed to this reverse order to gain temporary political merit.

## 4.5 RFP & RFI processes.

It is standard practice for government agencies to prepare both Request for Proposals and Request for Information when contemplating building new, modifying legacy or architecting a combination of the two to build a new and improved broadband network.

In consideration of developing the RFP and RFI's in your respective environments give considerations to the existing telecom carriers and their legacy practice of utilizing both private and public infrastructure for deployments, how government agencies handle requests for the use of real property assets and new

policies associated with collocations and streamlined or bulk permitting as means to advance deployments of all operators. Also give careful consideration to planning the use of City assets for next generation deployments such as C-RAN (Centralized Radio Access Node) architecture with RRH, BBU and front haul options.

Some other RFI information to consider in your release

- Fiber to the home
- Fixed Wireless Services
- Managed Wi-Fi Services
- IoT devices
- Public outdoor Wi-Fi
- Infrastructure Use
- New Spectrum Use

### 4.6 Assess current state of viable telecommunications infrastructure.

It should be a priority for municipal agencies to maintain a all viable citywide real property asset for multiple purposes. One of the now urgent priorities is assessing the viability of such city assets as they may accommodate current and next generation telecommunications infrastructure (both wireless & wireline). As such, this once previously ignored component of managing city-wide assets has now become one of the most critical factors in municipalities generating new found revenues and brokering in-kind next generation wireless and wireline broadband services. Additionally, the management of these assets will help the municipality lead new technology deployments to areas that meets the publics interests not just the private sectors ROI metrics.

Consider new capital investments for municipal spend on infrastructure to include:

- Conduit
- Dark Fiber
- Neighborhood hub sites for interconnection
- City furniture
- In-building wiring and pathways
- Interoperability tools & services
- Local aggregation points of presence
- Poles & Towers
- Core routing, switching and customer premises electronics

### 4.6.1 Management of telecommunications infrastructure.

Many municipal, state, federal, provincial, and regional authorities and Agencies have traditionally operated in silos when it comes to asset management of telecommunications infrastructure – both traditional and non-traditional. Many operate independently across many Agencies whom all have a common goal.

It has now become best practice amongst municipalities to create a Telecommunications Site Management Unit to establish a standard & uniform approach to managing all telecommunication assets belonging to or Licensed by City Agencies, as well as to third party entities located on City-owned real property assets. Another purpose of the Unit is to consolidate relations with telecommunication service providers and increase leverage and coordination among City, State or Regional agencies.

The Telecommunications Site Management Unit would provide the following services:

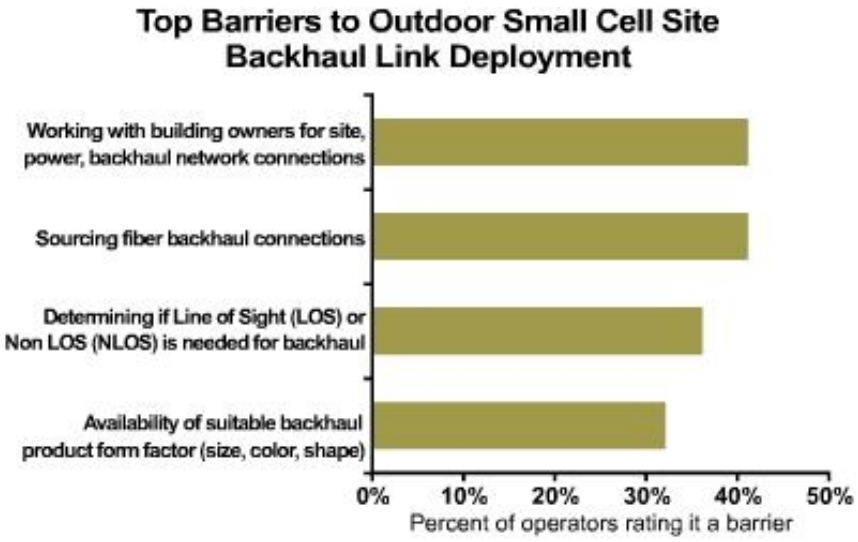
Site Assessment and Acquisition

- Site Engineering, Development and Construction
- Site Marketing
- Lease Management
- Telecommunications Site Auditing and Oversight
- Dig once policy oversight

**Pros**

- Subject Matter Expertise and oversight of existing telecommunications Licensees that may have been gained or granted by default
- Ongoing enforcement of City Building & Electrical Code standards with both existing and future Licensees
- Assessing & re-negotiating existing Licensees fair market values for major radio frequency equipment (Cellular and Public Safety) and all fibre and Wi-Fi equipment. This could increase current revenues by >100%.
- Standardizing all terms and conditions in existing & future License Agreements. Mandating Agreements be written and agreed to on City Agreements opposed to carrier Agreements.
- Warehousing and archiving all associated financial, legal, engineering, regulatory and administrative data for each Licensee in a specifically customized telecommunications database.
- Increasing the City's leverage with carrier's demands for use of Citywide real property assets and mitigating agency arbitrage (where providers go to different agencies to undercut the City's best interests).

- Actively influence the proliferation of broadband services to those most underserved in the marketplace.
- Ability to execute on a backlog of current demand from all major cellular carriers on Master License Agreements (giving carriers ability to License space on large amounts of properties and subsequently executing one-page Site License Agreements for each property use).
- A professional and unified approach to marketing properties to the telecommunications industry.
- Greater revenue and in-kind service returns with the ability to negotiate bulk agreements.
- A dedicated and specific Communications Site Management Unit focusing specifically on provisioning telecommunications infrastructure and services on a Citywide or Metro basis.
- A dedicated Financial reconciliation and collections Unit.
- Without this Unit, a loss of revenue to the City or State would be forever lost to the private sector as it will consume the current and future demand(s) of infrastructure use.




© Infonetics Research, *Small Cell and LTE Backhaul Strategies: Global Service Provider Survey*, Dec. 2012

## 4.7 Interagency technology assessments.

It is responsible for the City or municipality to lead efforts across all Agencies with urban and suburban metro areas in negotiated Master Service Agreements or the like for all existing and future telecommunications services to be provided to City Agencies. This prevents multiple, intermittent and fragmented approaches to procuring various telecommunications services which should be brokered collectively to gain economies of scale and leverage over telecommunications providers as City annual spends reach well into the millions.

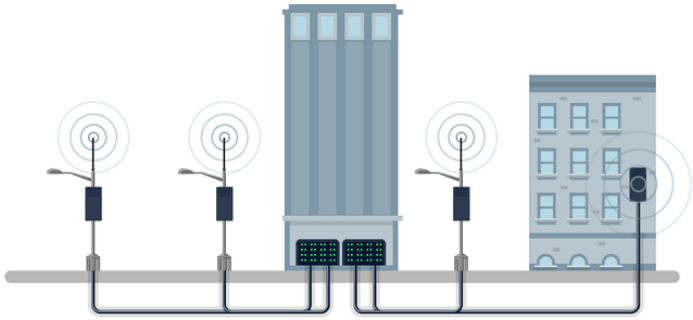
Consider summoning all Commissioners or Agency Heads to discuss their existing and future telecommunications needs and assess what can and should be done to upgrade/modify legacy networks and plan for future networks, especially Smart City and IoT devices and solutions. Concentrate heavy discussions with Agency leaders in the educational, health care, public safety and transportation sectors around new telecommunications performance and quality of service needs.

Have each telecommunications provider commit to establishing innovation or community technology and or computer labs so that the City can review and analyze next generation deployments and strategies that may impact their respective environments, neighborhoods and technology solutions and strategies.

### 4.7.1 Franchise Agreements and their renewals.

Many Cities have existing and new Franchise Agreements which they negotiate and administer franchises with private telecommunication and broadband companies that use City streets and sidewalks to provide telecommunications services. These types of franchises consist of:

- Cable & fiber providers
- Broadband Services
- Public Pay Telephones
- Mobile Telecommunications
- Public & Parks Wi-Fi
- Digital Bus Shelter

Many of these and other Franchises will have to evolve to accommodate next generation technologies, infrastructures, services and solutions.

One of the biggest challenges that City Officials must face is how to incentivize new broadband infrastructure (fiber) layered atop or complementary to existing infrastructure. One of the strategies to consider is to establish 'broadband enterprise zones' where either incumbent or new Franchisees would not have to pay costly City imposed Franchise fees to deploy new conduit, cable or fiber infrastructure throughout the broadband enterprise zone.

This policy would stimulate new telecommunication services to underserved areas or neighborhoods that have been traditionally ignored by incumbent providers.

The use of street light poles has become one of the most sought-after city assets for the deployment of next generation technologies. There is an abundant use of the streetlight poles accommodating legacy telecommunications operations now but the new demand for use is astronomical. Many of the street light poles in critical high dense locations throughout urban and suburban metro areas have already been exclusively leased or licensed to one independent carrier without collocation considerations. Thus, the effect has been saturated use of critical poles in high dense areas without policy to accommodate future needs of next generation technologies on those same critical poles.

Amongst some of the best practices for policy around the use of city street light poles and wooden utility to accommodate telecommunications equipment include:

Consider policies of deploying multiple spectrum antenna(s) with remote radio head (RRH) units on existing poles with home fiber to the antenna. Have manufacturers of such antenna design models which aesthetically blends into the existing poles architecture or within the City's architectural scheme without unsightly blight. These sites would be connected to a local aggregation point of presence or local data center either managed by the City or by a third-party system integrator.

Consider a smart pole model which could provide City LED Luminaire solutions as well as accommodate multi-tenant small cell and or other wireless technologies, i.e, Wi-Fi, IoT sensors, public safety or transportation technologies embedded all into a sleek next generation street light pole.

Many of these models can be found in forward thinking City's landscapes to include, Los Angeles and San Jose, CA, Dubai and

## 4.8 Broadband Pilots.

Many cities are moving forward with next generation broadband pilots or testbeds to explore various smart city, colocation strategies and network slicing use cases which might be deployed over large geographic areas of the metro areas. Many different private public partnerships have materialized over the development of these prospective testbed to include academia institutions, OEM's, City Agencies and private investors.

See the Nokia 5G-MoNArch project as a sample 5G testbed deployment.

Some of the deployment challenges to watch out for on broadband pilot deployments include:

- Permitting
- Interoperability
- Fiber Deployment Obstacles
- Manufacturing/Assembly/Truck Rolls
- Ancillary Services (sensors, small cells)
- Privacy/Security
- Political influences

## 4.9 Federal Pre-Emption on Real Estate Wireless Cell Siting

### 4.9.1 Background:

There seems to be a partisan consensus in Washington, D.C., over locating next generation cell sites. The greatest divide is between federal and local governments. After making the obligatory nods toward local communities, top aides to five FCC commissioners agreed that clearing the path for the millions of new cell sites that 5G networks will require is a top priority. Most of the FCC Commissioner's agree that in order to make 5G work, the cost of constructing cell sites, particularly the time and money required to get permit approval from cities and counties, is paramount.

Limits on access to the public right of way by local governments must be trimmed back or eliminated completely, restrictions on locations need to go and lengthy permit approval processes must be shortened, according to many experts on the subject. However, not much consultation has occurred with local municipal leaders especially those from major Tier 1 cities across the United States.

Our society is amid a technological revolution regarding broadband infrastructure deployment, particularly for data-intensive wireless services. Demand for wireless capacity is increasing: more consumers are accessing mobile broadband every year, driving more innovation and expanding access to public safety. But our ability to meet this demand depends on the infrastructure that supports the services. For this reason, in 2014 the Federal Communications Commission adopted a Wireless Infrastructure Report and order that takes steps to further promote deployment of the wireless infrastructure necessary to provide the public with ubiquitous, advanced wireless broadband services.

View The Wireless Infrastructure Report

### 4.9.2 Tower Siting

The Report and Order updated the manner in which the Commission evaluates the impact of proposed deployments on the environment and historic properties. The Commission's environmental review procedures had excluded collocations of antennas from most of the requirements, recognizing the benefits of using existing structures over constructing new ones. In order to facilitate

faster deployment of wireless infrastructure, the rules now expand that categorical exclusion to include: equipment associated with the antennas (such as wires, cables, and backup-power equipment), certain deployments on existing utility poles and electric transmission towers, and collocations within a building.

The Report and Order also expanded the situations in which small antennas collocated on existing structures are excluded from historic preservation review. A **2016 agreement with the Advisory Council on Historic Preservation and National Conference of State Historic Preservation Officers** further streamlined this review for small facility deployments.

The rules were crafted to spur greater deployment of new technologies, such as small cells and distributed antenna systems, which multiply wireless capacity within existing spectrum resources. Small cells are low-powered radio access nodes that operate in licensed and unlicensed spectrum with a range of 10 meters to 1 or 2 kilometers and can be deployed relatively easily on utility poles, street lamps, water towers, or rooftops.

### 4.9.3 State and Local Governments

The rules clarify and implement federal statutory directives that are intended to make State and local review more efficient for wireless deployments and modifications while preserving the Commission's commitment to safeguard the essential roles that State, local, and Tribal governments play in this process. To provide certainty and encourage efficient review, the FCC has adopted "shot clocks" that establish time frames within which State and local governments must complete their reviews. The shot clocks, which implement federal statutes, generally provide more time to review large-scale projects that may have comparatively large impacts and less time for collocations or modifications to existing deployments.

The rules arguably preserve local governments' authority to adopt and apply the zoning, safety, and concealment requirements that are appropriate for their communities. The Commission has been forging ahead aggressively to ensure that the United States is the world's 5G leader, placing particular emphasis on expanding access to spectrum, enabling backhaul connections, and promoting infrastructure deployment.

### 4.9.4 Temporary Towers

If an antenna structure (1) will be in place for 60 days or less; (2) requires notice of construction to the FAA; (3) does not require marking or lighting under FAA regulations; (4) will be less than 200 feet above ground level; and (5) will involve minimal or no ground excavation, then the owner of the tower does not need to provide 30 days of national and local notice to give members of the public an opportunity to comment on the proposed tower's potential environmental effect.

### 4.9.5 Streamlining Deployment of Small Cell Infrastructure by Improving Wireless Facilities Siting Policies

On December 22, 2016, the Wireless Telecommunications Bureau issued a Public Notice inviting public input on potential Commission actions to help expedite the deployment of next generation wireless infrastructure by providing guidance's on how federal law applies to local government

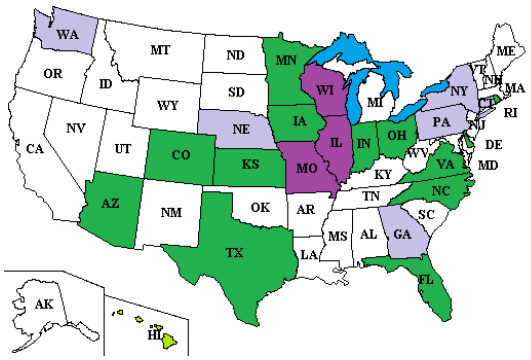
review of wireless facility siting applications and local requirements for gaining access to rights of way.

See link to the **Public Notice** and **Order** extending comment period.

An overview of the FCC's Rules and Policies on Tower and Antenna Siting is available **here.**

### 4.9.6 Current Status:

There are two FCC documents on the topic of preemption of local regulations. The **Wireless Infrastructure NPRM** (WT Docket Nos. 17-79 and 15-180) and the **Wireline Infrastructure NPRM** (WC Docket No. 17-84) address, in part, the issues. These are the only recent documents the FCC has released on preemption of local rules/regulations, with the exception of the creation of the Broadband Deployment Advisory Committee, which is focused on creating model rules, not truly on preemption. See the Broadband Deployment Advisory Committee here.




| US Federal pre-emption Bill Passage by State | |
|---|---|
| Light Purple = | Bill has been introduced |
| Dark Purple = | Passed one House of Legislature |
| Light Green = | Passed both Housed |
| Dark Green = | Has been signed |
| White = | Not introduced, vetoed or Committee terminated |

Currently the Wireless Broadband Alliance is managing a watchdog table for the United States on a National level in which it plans on expanding to other countries and continents to the extent there are laws and policies that regulate the use of citywide or regional infrastructure as it applies to existing and or future telecommunications infrastructure, rights of way and or real property assets. The WBA table is attached.

**View The US Small Cell Laws Document**

### 4.9.7 Issues and Concerns:

Primary concerns from local municipalities which could be effected by such Federal pre-emptions for the deployment of next generation infrastructure include, but are not limited to;

- The perceived loss of sovereignty over local real property assets of which have unique real market value for citing telecommunications equipment
- The perceived loss of leverage over public assets as it relates to brokering for in-kind next generation telecommunications services and or solutions for the local municipality, i.e., (Public Safety, Transportation, Education, Utility, Industrial, Government Services)
- Continued blight and or cluttering of municipal neighborhoods with unsightly and unregulated deployments of telecommunications equipment in many aesthetically sensitive areas

Federal pre-emptions do not foster multi-tenancy or multi-use infrastructure needed to accommodate higher capacity for wireless technology deployments

## 5 Assessing the role of different technologies

The connected city technology landscape contains many different wireless access technologies and can seem bewildering to the uninitiated. The key is to understand that each wireless access technology is designed for a specific purpose, with a specific application or set of applications in mind. The application supported by a wireless access network technology depends on the design of the protocol, the frequency band of operation and the limitations enforced by local and international regulatory authorities.

### 5.1 Technology Landscape

Today's wireless technology landscape is crowded and each of the contenders highlights specific qualities and capabilities making it complex for decision makers in cities to understand where to start. The reality however is that with a clear and objective view of planned applications and needs the resulting options can be narrowed down. No single wireless technology is ideal for all use cases, cities and their 3rd party providers will need to pursue, and plan for, a hybrid approach.

It will be clear that the technology of choice for CCTV with high bandwidth needs will be different from the optimal wireless connectivity for parking sensors. Also, one needs to take into consideration if sensors are operated on batteries or connected to the power grid, or any other kind of external power like in a connected vehicle. Many sensors in a Connected City will be stationary and in difficult to reach / atypical locations which may require battery operation, where possible supported by energy harvesting to allow for an extended lifecycle. This explains why there is currently so much interest in Low Power Wide Area Network technologies, as further explained in section 5.6.1 topic 3.

However, the need for speed (bandwidth) seems not to stop and in specific use cases like autonomous cars also latency are a crucial factor. The industry has recognized these needs and is developing new technologies under the so called 5G framework. For cities, or their wireless network operators, this will mean a further densification of access points in the future.

Given the wide variety of use cases, as also described in table 6-1, it will be clear Connected Cities will require multiple technologies to capture the full potential of IoT while also meeting the ever-increasing access requirements for citizens and broadband applications such as video.

## 5.2 Regulatory Authorities:

The International Telecommunications Union (ITU) is an international body responsible for allocating radio spectrum to different applications, registering frequency assignments made by member states and developing technical standards used to ensure global technological compatibility and interoperability.

Local regulatory authorities in each radio region take their cues from the radio spectrum assignments and regulations made by the ITU for their radio region. It is important to understand both the international and local radio regulations and how they affect the performance and applicability of different frequency bands for specific tasks. Typical regulatory requirements and limitations include:

- Intended Application
- Digital or Analog Operation
- Maximum Transmit Power / Power Spectral Density / EIRP
- Maximum Duty Cycle
- Unlicensed / Licensed operation

## 5.3 Wireless Access Protocol Characteristics

Wireless access technologies are most often developed with prior knowledge of the regulatory framework in each global radio region and are intended for use in specific frequency bands. A protocol is often also limited by the regulatory requirements of the frequency band it operates in. The key requirements when validating a specific wireless access technology for a given task include:

- Coverage
- Spectral Efficiency & Maximum Throughput
- Technology Adoption & Client Availability
- Client Capacity (I.e. maximum number of clients that can be served simultaneously)
- Data Capacity (i.e total data per hour that can be moved)
- Quality of Service
- Security
- Power Requirements

## 5.4 Wireless Access Technology Types

In general, it is possible to divide wireless access technologies into groups according to their function

### 5.4.1 Personal Area Networks

Personal Area Network technologies are designed to provide connectivity between two devices located within several metres of each other. These technologies typically do not forward data across a network, but rather act to allow direct exchange of information between two devices. Personal Area Network technologies typically operate at very low power in the unlicensed bands and include technologies such as near Field Communication (NFC), Bluetooth and Bluetooth Low Energy (BLE), Zigbee, and ZWave. Due to their low power consumption Personal Are network technologies are often used with battery powered devices. A Bluetooth low energy beacon can provide service for at least 5 years using a single 3000mWh, 3.0 Volt battery. A Bluetooth headset that streams audio from a smartphone will typically have a battery life of less than 12 hours and will require recharging. A table of Personal Area Networking technologies and their attributes is provided in Table 3 below.

| Technology | Frequency | Range | Throughput | Applications |
|---|---|---|---|---|
| **NFC** | 13.56 MHz ISM | Typ: < 5cm<br>Max: < 20cm | < 424 Kbps | • Contactless Payment<br>• Electronic Ticketing<br>• Identity |
| **Bluetooth BR/EDR** | 2.4GHz ISM | Typ: < 10m<br>Max: < 400m | < 2 Mbps | Continuous Wireless Connections<br>• Speakers, Headsets, in Car Systems etc. |
| **BLE (5.0)** | 2.4 GHz ISM | Typ: < 3m<br>Max: < 100m | < 2 Mbps | • PC Peripherals, Sport & Fitness, Health & Wellness<br>• Point of Interest Beacons, Wayfinding Beacons<br>• Building Automation, Wireless Sensor Networks, Asset Tracking |
| **ZigBee** | 2.4GHz ISM<br>900 MHz<br>868 MHz | Typ: < 20m<br>Max: < 300m | < 250 Kbit/s<br>< 40Kbit/s<br>< 20Kbit/s | • Industrial Automation & Control<br>• Home & Building Automation<br>• Embedded Sensing<br>• Medical Data Collection |
| **ZWave** | 868 / 900 MHz | Typ: < 30m<br>Max: < 100m | < 100Kbit/s | • Home / Building Automation<br>• Smart Home Products |

**Table 3: Personal Area Networking Technologies**

### 5.4.2 Local Area Networks:

Local Area Networks cover indoor and outdoor areas within a range of up to several hundred metres, and provide the ability for the city to switch high speed data traffic directly onto their own network. Local Area Networks are typically wholly owned and managed by the city or a contracted 3rd party and typically operate in the 2.4GHz ISM and 5GHz unlicensed bands. The predominant protocol for Wireless

Local Area Networks is the 802.11 Wireless LAN standard published by the IEEE, more colloquially known as "Wi-Fi". Wi-Fi offers high data throughput of up to several hundred Megabits per second in most practical scenarios and can be used to provide public internet access, CCTV camera backhaul, location based services and other city services. Wi-Fi Access Points are typically light and are able to be directly integrated into streetlamps or mounted on available street furniture including signposts, traffic lights, and purpose built interactive signboards. Wi-Fi Access Points can provide power and connectivity to IoT protocol gateways enabling a city to reduce costs and deploy multiple network access technology types using a consolidated network infrastructure.

### 5.4.3 New & Emerging Technologies

In addition to Wi-Fi, new protocols based on LTE are currently entering the market and are under trial. MulteFire is a modified version of LTE based on 3GPP Release 13 (LAA) and Release 14 (eLAA), and utilizes a Listen Before Talk / Clear Channel Assessment channel access method. MulteFire operates in the 5GHz unlicensed band and can be extended to 3.5GHz band operation. MulteFire supports network architectures including PLMN Integration, Neutral Host Networks and Local Area Networking. It is not yet clear how the adjustments made to MulteFire specifically in the channel access method will affect the overall performance of the system, but trials are ongoing. MulteFire is also able to interoperate within the CBRS framework detailed below.

CBRS (Citizens Broadband Radio Service) is the name given to a specific section of the 3.5GHz band (3GPP Band 48) set aside by the Federal Communications Commission for public use in the United States. The Citizens Broadband Radio Service employs a 3-tier spectrum licensing model, allowing incumbent users (including the US Navy) to continue their operations unhindered. Interested parties including private enterprises, municipalities, MNOs and ISPs are able to make use of the 3.5GHz band using either a Priority Access License (PAL) or General Authorized Access (GAA) which provide dedicated access to spectrum resources in small geographical areas on a first-come first-serve basis. The Priority Access License enables the use of up to four 10 MHz wide channels within a census tract for a period of several years. The General Authorized Access license is free to use, with dedicated frequency channels assigned dynamically by a centralised Spectrum Access System. Spectrum Access Systems are being developed by several parties and their services will be available on the open market ensuring healthy competition on pricing and service. Outside of the united states some operators are looking to TD-LTE in the 3.5GHz band as a replacement for legacy WiMAX networks. Vendors are currently developing TD-LTE based small cells in the 3.5GHz band (3GPP Band 42, 43 and 48) for use in LTE networks worldwide. Additional details on CBRS follow.

The attraction of LTE based protocols in private networks includes

- The ability to use hitherto unavailable spectrum (3.5GHz Band, US Only)
- Seamless integration into mobile packet cores
- Improved receive-sensitivity and improved uplink radio performance at range.
- Enhanced support for real time protocols such as voice and video calls with reliable quality of service due to the scheduled channel access methods.

### 5.4.4 Wide Area Broadband Networks:

Wide Area Networks cover large geographical areas with distances typically on the order of up to tens of kilometres in rural or suburban environments. Coverage in urban environments is limited to smaller areas of several kilometres. Wide Area Network technologies can be divided into broadband network technologies and narrowband network technologies.

Broadband network technologies are designed to provide high speed data throughput for internet access, file downloads and transfers, and real-time communication services including voice and video streaming. Examples of wide area broadband technologies include WiMAX, CDMA2000 EV-DO, Ultra Mobile Broadband, UMTS and LTE and typically operate exclusively on licensed spectrum. Older technologies like WiMAX and CDMA 2000 EV-DO are currently being replaced by LTE networks worldwide

### 5.4.5 New & Emerging Technologies

**5G**

5G is more than just a new generation of mobile technologies, 5G will see a major shift in how cellular networks are designed and what they are used for. Mobile operators will use new network architectures, as well as new radio technologies, to achieve the flexibility required to serve an extremely diverse set of applications from mission critical communications between machines to highly immersive entertainment and fingertip control over remote devices and appliances. Advanced software will enable the mobile network to adapt to the needs of the service, rather than the other way around.

5G will boost bandwidth. As the number of connections grows inexorably and video streams becoming increasingly high definition, mobile operators will need the network capacity and performance provided by 5G to meet demand for immersive entertainment anywhere, at any time. For example, 5G will be able to deliver live virtual reality streams from sports events and concerts, while enabling detailed digital information to be superimposed on live images of the physical world captured on a smartphone or head-mounted display (augmented reality). Thanks to a step-change in latency, 5G could be used to control robots working in unpredictable conditions or fast-moving objects, such as drones, using a virtual reality headset. Moreover, 5G could play a pivotal role in providing the responsive and ubiquitous connectivity required by autonomous vehicles to function safely.

Mobile operators, equipment vendors and research institutions in East Asia, Europe and North America are the main drivers behind the development of 5G. At a global level, the GSMA is working with its members and other industry bodies to deliver the strategic, commercial and technological requirements of a 5G system. Policymakers at a national level and an international level are also heavily involved, with the International Telecommunications Union (ITU) and the European Union both seeking to coordinate the availability of the necessary spectrum. Umbrella standards group 3GPP is also playing a key role in refining the 5G specifications and ensuring interoperability.

### 5.4.6 Wide Area Narrowband Network Technologies

Narrowband or Internet of Things (IoT) and Machine to Machine (M2M) technologies are typically designed to work with low throughput data streams and small amounts of infrequent data, including aggregated measurement data and events from remote sensors

| Technology | Frequency | Bandwidth | Throughput | Network Type | Sample Applications |
|---|---|---|---|---|---|
| **SigFox** | 865 / 900MHz | 100Hz | 100 bit/s | Public | - Smart Metering<br>- Street Light Management<br>- Remote Sensors<br>- Location tracking<br>- Security / Alarms |
| **LoRa** | 865 / 900MHz | 125KHz – 250kHz | < 50Kbit/s | Operator / Private | |
| **NB-IoT** | LTE Freq. Bands | 200kHz | < 50 kbit/s | Operator | |
| **LTE-M** | LTE Freq. Bands | 1.4MHz | < 375 kbit/s | Operator | - M2M Communications<br>- VoLTE |

While it is possible for a city to own all the infrastructure to run a wide area network, often these are provided as a service to the city by an operator who owns the necessary spectrum licenses and/or the necessary network core. It is important to note that traffic from most Wide Area Networks must traverse the provider/operator's core network before it can be delivered to its final destination.

| | Broad Band – High Data Throughput | IoT / M2M Communications |
|---|---|---|
| **Local Area Network** | Wi-Fi<br>Wi-Gig<br>CBRS (US Only)<br>MulteFire | Wi-Fi - Halow<br>Bluetooth<br>Zigbee<br>ZWave |
| **Wide Area Network** | 802.20 - Obsolete<br>WiMAX - Legacy<br>GSM<br>UMTS / CDMA / CDMA 2000<br>LTE | Sigfox<br>LoRa<br>NB-IoT<br>LTE-M |

### 5.4.7 The Need for a Hybrid Approach

No single wireless access technology can be used to meet all the requirements of a connected city.

Wi-Fi could be used to provide public internet access and simultaneously transport CCTV camera footage over a short distance of several hundred meters outdoors without requiring a cabled backhaul. The benefit of this approach is that unlicensed frequencies attract no regulatory fees and traffic can be switched directly into the city's fiber network. Wi-Fi may be unsuitable as a technology for smart-metering due to its power requirements (typically upwards of 7 watts) and limited building/ground penetration by signals in the 2.4 & 5GHz bands.

Millimeter wave technologies with frequencies in the tens of GHz, such as 802.11ad/Wi-Gig (60GHz) and 80GHz microwave links can be employed where very high throughput backhaul is required over short hops of less than 2 kilometres. This is a useful technology for aggregating feeds of data and providing a high speed wireless backbone where multi-gigabit fiber is unavailable.

Low Power WAN Technologies that operate in the sub 1GHz frequency bands typically offer much better coverage, better building penetration and require considerably less power. Often Low Power WAN devices are capable of running for years on a single relatively small battery or even permanently with a small solar panel attached. These technologies are best suited to sensor networks that collect, aggregate and forward periodic data or send notification when triggered by certain events. Both SigFox and LoRa are also capable of providing location tracking without the assistance of GPS, provided that sufficient gateways are within range of a sensor. LPWAN technologies are ill suited to applications requiring constant or high capacity data throughput.

Zigbee, Bluetooth and ZWave are IoT protocols that operate in the unlicensed 2.4GHz ISM band, and are most suited to indoor use and very short range connectivity, often within a single room, or for indicating presence at a bus stop etc. Blue Tooth Low Energy is a technology used for beacons that cen detect when a client device is within <1m of the beacon. These technologies are characterized by their low power consumption

Licensed technologies (including LTE, LTE-M, and NB-IoT) play a significant role in mission critical applications where unlicensed bands are highly congested, interference cannot be tolerated, or guaranteed quality of service is required. LTE provides a useful wide area network technology for high data throughput, whilst LTE-M and NB-IoT provide additional options for Machine to Machine communication and IoT connectivity respectively.

LTE-U and LAA offer the ability for LTE based technologies to make use of Emerging technologies such as TD-LTE in the 3.5GHz band (referred to as CBRS in the United States) and Multefire enable the use of LTE technologies in unlicensed and semi-licensed bands. These technologies can deliver some benefits over other protocols specifically for real time
voice / video communications, but as of 2017 their adoption is still in its very early stages.

It is likely that devices will make use of multiple access technologies to complete different tasks. For instance, a sensor may use an IoT protocol to send telemetry data, whilst firmware updates may be effected using Wi-Fi or LTE. In addition, there may be devices using multiple access technologies of similar types in an effort to deliver cost/performance optimizations or more universal deployment in

diverse environments. An example of this is a sensor that allows LoRa, SigFox and NB-IoT connectivity and in addition possibly Wi-Fi, LTE or other forms of connectivity for scenarios requiring high data throughput.

## 5.5 Wireless Broadband Technologies

### 5.5.1 Unlicensed Wireless Technologies

**Wi-Fi**

Wi-Fi operates in 2.4GHz and 5GHz ISM bands and is the most widely adopted broadband technology, with over 15 billion devices Wi-Fi capable as of the end of 2016 (Wi-fi Alliance, ABI), eight (8) times more than LTE. Wi-FI Local Area Networks (WLANs) cover indoor and outdoor areas within a range of up to several hundred metres, and provide the ability for the city to switch high speed network traffic directly onto their own network. Wi-Fi Networks may be wholly owned and managed by a city, provided to the city as a service by a 3rd party, or owned and operated as private business initiatives serving the general public. The current generation of Wi-Fi, 802.11ac Wave 2 offers high data throughput of up to several hundred Megabits per second in most practical scenarios and can be used to provide public internet access, CCTV camera backhaul, location based services and other city services. New Wi-Fi standards have been introduced every ~3 years and the next generation 802.11ax standard is expected to be introduced in Enterprise/Carrier class Wi-Fi systems in the 2nd half of 2018. Wi-Fi Access Points are typically lightweight and are able to be directly integrated into streetlamps or mounted on available street furniture including signposts, traffic lights, and purpose built interactive signboards. Wi-Fi Access Points can provide power and connectivity to IoT protocol gateways enabling a city to reduce costs and deploy multiple network access technology types using a consolidated network infrastructure.

There is also a Wi-Fi Direct standard which enables peer-to-peer communication among devices without need of an AP.

**LWA/LWIP**

LTE-WLAN Aggregation (LWA) and LTE WLAN Radio Level Integration with IPsec Tunnel (LWIP) were developed in Release 13 from 3GPP. These solutions use the 3GPP E-UTRAN as an anchor point where the WLAN is connected to the eNB, thereby also eliminating any impacts on the Mobile Core Network. Furthermore, making the offloading decisions at the access network can reduce signaling. It is assumed that an eNB is connected to WLANs that are under its coverage as LTE connectivity is required for these solutions.

LWIP was designed to minimize the impact to legacy WLAN while LWA is based on Dual Connectivity split-bearer solution for proven substantial performance gains compared to other LTE/WLAN integration solutions.

**MulteFire**

LTE can also be deployed in unlicensed spectrum (e.g., 3.5 GHz, 5 GHz) without being anchored with a licensed carrier. With this option, unlike LAA or LWA/LWIP, all the signaling and data are carried

over the unlicensed carrier. The primary motivation for this is to combine the enhanced performance of LTE (capacity, range, and mobility) with the deployment simplicity (similar to Wi-Fi) of unlicensed spectrum. This can broaden the LTE ecosystem to more entities such as ISPs, cable operators, and enterprise/venue owners and enable both offloading and neutral host deployments.

One initiative to enable standalone unlicensed operation of LTE is the MulteFire Alliance (www.multefire.org) which announced its formation in December 2015. The Alliance is currently working on developing the MulteFire technical specifications as well as establishing a product certification program. A key principle for this design will be fair co-existence with Wi-Fi which will be based on methods used by LAA.

**CBRS**

CBRS (Citizens Broadband Radio Service) is the name given to a specific section of the 3.5GHz band (3GPP Band 48) set aside by the Federal Communications Commission for public use in the United States. The Citizens Broadband Radio Service employs a 3-tier spectrum licensing model, allowing incumbent users (including the US Navy) to continue their operations unhindered. Interested parties including private enterprises, municipalities, MNOs and ISPs are able to make use of the 3.5GHz band using either a Priority Access License (PAL) or General Authorized Access (GAA) which provide dedicated access to spectrum resources in small geographical areas on a first-come first-serve basis. The Priority Access License enables the use of up to four 10 MHz wide channels within a census tract for a period of several years. The General Authorized Access license is free to use, with dedicated frequency channels assigned dynamically by a centralised Spectrum Access System. Spectrum Access Systems are being developed by several parties and their services will be available on the open market ensuring healthy competition on pricing and service. Outside of the united states some operators are looking to TD-LTE in the 3.5GHz band as a replacement for legacy WiMAX networks. Vendors are currently developing TD-LTE based small cells in the 3.5GHz band (3GPP Band 42, 43 and 48) for use in LTE networks worldwide. Additional details on CBRS follow.

The attraction of LTE based protocols in private networks includes

- The ability to use hitherto unavailable spectrum (3.5GHz Band, US Only)
- Seamless integration into mobile packet cores
- Improved receive-sensitivity and improved uplink radio performance at range.
- Enhanced support for real time protocols such as voice and video calls with reliable quality of service due to the scheduled channel access methods.

### 5.5.2 Licensed Wireless Technologies

**GSM (3G/4G-LTE)**

GSM (Global System for Mobile Communications) is the world's most popular licensed wireless phone technology. It's used by billions of people around the world, in more than 220 countries, and normally delivers nationwide coverage. GSM offers unparalleled global roaming capabilities, as well

as the truest voice quality in wireless. Its easy-to-use data capabilities offers fast wireless data broadband connectivity.

There are several technologies and levels of services within the GSM "family", including LTE, HSPA+, HSPA, UMTS, EDGE, GPRS. Including recent Cellular IOT standards aimed at IoT such as LTE Cat M and NB IoT (see section 5.3.2). As technologies keep evolving, and also being sunset like 2G, the current focus is on the definition of a framework for 5G by 2020 which is merely aimed at extreme low latency and high bandwidth for solutions like autonomous cars. Standardization has just started in 3GPP but based on NGMN and ITU/ETSI initial assessment the use cases for IoT are also a key element of the 5G technologies.

**LTE (U)**

Long Term Evolution (LTE-U) is a radio access technology that has been proposed by the members of the LTE-U Forum for providing carrier-grade wireless service in the 5GHz unlicensed band.

LTE-U operates using unlicensed spectrum as a Supplemental Downlink to primary LTE technology operations that use licensed spectrum. LTE-U has some modifications to the normal LTE radio signal, but is predominantly a shift of the LTE signaling and protocol to the 5GHz band. As such, the primary use for LTE-U is the quick time to market, as a "pre-standard" technology, leading toward LAA, but with minimal changes needed to traditional LTE deployments and equipment to enable quick adoption.

**LAA**

Licensed Assisted Access (LAA) is a technology that enables operators that have access to licensed spectrum to complement it with unlicensed spectrum while leveraging the existing and planned investments in LTE/EPC, i.e., hardware and software in the radio and core network. The access to unlicensed spectrum is done via a Secondary Component Carrier (SCell) which is assisted by a Primary Component Carrier (Pcell) on licensed spectrum using the Carrier Aggregation Framework of LTE.

**LAA**

LAA is part of 3GPP Release-13 and the main objective is to deliver enhancements to LTE for operation in the 5 GHz band. Fair co-existence with other technologies operating in unlicensed spectrum is a fundamental design principle for LAA. Based on the principle of carrier aggregation, the LAA designs aim to combine the best of the licensed and unlicensed band opportunities while reducing operators' operating costs

### 5.5.3 Coordinated Shared Spectrum Wireless Technologies

**CBRS**

On April 17, 2015, the FCC issued a Report and Order (R&O) detailing a new Citizens Broadband Radio Service (CBRS) in the 3550-3700 MHz band. The R&O provided a framework within which incumbent users (including the DoD, Satellite Ground Stations, and Fixed Wireless Internet Service

Providers) would continue to operate, but would share the band with new commercial entrants who could utilize the band on a shared-access basis. Shared-access would be available in two forms:

- Priority Access Licenses (PALs) will provide priority shared access to a certain amount of bandwidth at the geographic level of a census tract. PALs will be granted for terms of 3 years. They will only be granted in the 3550-3650 MHz range, the maximum amount of the 3550-3650 MHz range that may be allocated for PAL operation is 70 MHz in any one census tract. There are limits on how much spectrum a single licensee can hold via PAL (40 MHz), as well as requirements for competitive bids to ensure a single entity doesn't monopolize the spectrum via the PAL. PAL operation is subject to preemption and frequency reassignment in the event that an incumbent begins operating on a frequency that has been assigned to a PAL user. This is why the PAL license is for a certain amount of bandwidth, but doesn't stipulate a static frequency range since that may change from time to time.
- General Authorized Access (GAA) is somewhat analogous to traditional unlicensed spectrum in that anyone may request use of CBRS spectrum at a given location on an opportunistic basis. The entire 3550-3700 range may be granted for GAA operation. GAA operation is subject to preemption and/or frequency reassignment from both incumbents as well as PAL users. Additionally, the R&O does not provide protections between multiple GAA users who may be operating in the same location. [GAA coexistence optimization, while not guaranteed by the regulations, is being investigated via coexistence mechanisms being studied in various industry organizations.

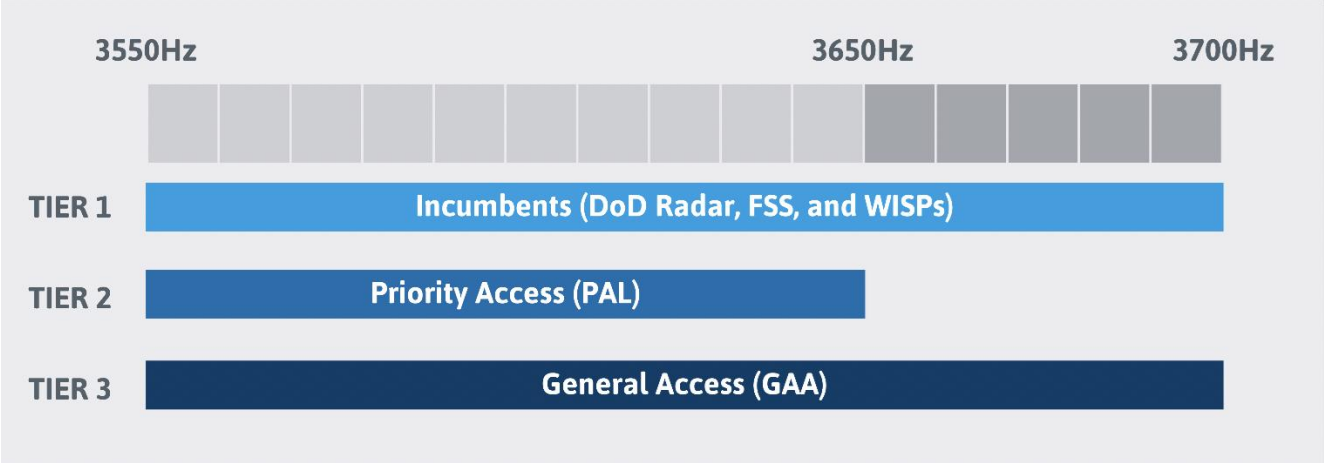



**Figure 12: Citizen's Broadband Radio Service, 3 Tier Framework**

The following list represents key characteristics, or attributes, of CBRS.

Supports dynamic and flexible allocation of the band between incumbent, short term licensed, and opportunistic uses, with apportionment varying geographically and over time. The shared access distribution between short term licensed and opportunistic use can adjust dynamically in response to the PAL auctions and ongoing demand for GAA spectrum grants.

Compared to a 2 Tier framework, the CBRS framework may foster a broader ecosystem since the framework supports operations of any entity which is in compliance with the operational requirements and has registered with a SAS provider.

Compared to a 2 Tier framework, the CBRS framework may encourage investment by a wider variety of potential operators; including mobile service providers, fixed service providers, property owners, and enterprises.

CBRS is a radio protocol agnostic framework that can support technologies that have historically operated in exclusive spectrum as well as those that have been developed to operate on a shared channel basis.

The CBRS Rules and Order, and Part 96, provide the operational requirements for shared access use (both short term licensed and opportunistic) of the band. As such there is no need for shared access users to directly coordinate or negotiate with incumbents before commencing operation. The framework accommodates neutral-host / multi-operator deployments where 3rd parties manage networks supporting subscribers of multiple mobile operators.

### 5.5.4 Heterogeneous Networks

Further methods to address the growth of data traffic over the wireless networks is to deploy small radio cells where traffic demand is high or to offload the low-value data traffic to Wi-Fi networks. The natural progression of the reduction of cell sizes, offload of data from the central backhaul network and other technologies including the better use of the radio spectrum is generally referred to as Heterogeneous Networks. When considering that the new 5G Radio Access Technology may be designed to operate at very high frequencies and therefore deployed as small cells, heterogeneous networks become a particularly significant enabler not only in the short term, but also in the long term.

To meet the intensified demand for data capacity and speed levels, operators can expand an existing macro network and densify it by adding more sectors per eNB or deploying more macro eNBs. Reducing the site-to-site distance in the macro network can only be pursued to a certain extent because finding new macro sites becomes increasingly difficult and can be expensive, especially in city centres. An often-better alternative is to introduce small cells through the addition of low-power base stations (eNBs, Home eNodeBs (HeNBs) or Relay Nodes) or a Remote Radio Head (RRH) to existing macro eNBs. Site acquisition is easier and cheaper with this equipment, which is also correspondingly smaller

A different approach to reducing the strain on LTE networks is to offload traffic to other radio access technologies. Offloading traffic to Wi-Fi looks particularly interesting. Wi-Fi can provide significant data capacity, as its carrier bandwidth is very wide (160MHz BW in the latest Wi-Fi specifications), its unlicensed spectrum is very large (580MHz total in 5GHz), it is low power and equipment is relatively cheap thus resulting in easy deployment of numerous cells. However, Wi-Fi offload presents some challenges when it is desirable to deliver a seamless experience for the user. While 3GPP has specified mechanisms to allow service continuity between 3G and LTE with relative ease due to the

fact that both technologies were under its control, the service continuity between Wi-Fi and LTE has been harder to achieve. However, Wi-Fi and LTE interworking has been improved and service continuity can be supported by connecting Wi-Fi to EPC.

As any technology can be deployed in the unlicensed spectrum, work is ongoing in 3GPP to define interworking between LTE base stations operating in the licensed spectrum and LTE base stations deployed in the unlicensed spectrum. This activity is known as Licensed Assisted Access LTE (LAA-LTE) and when completed will further enhance the capabilities of heterogeneous networks

Heterogeneous networks benefit and requirements, the state of the art for heterogeneous networks is dual connectivity and traffic offload (either to Wi-Fi or using Licensed Assisted Access to LTE).

## 5.6 IoT and Smart Cities Technologies

### 5.6.1 Alternative Unlicensed Access Technologies

For the unlicensed technologies, there is always a balance between range and data throughput, given the fact the regulators put constraints around the use of a band to ensure accessibility and fair use. A derived aspect when keeping range in mind when building out networks is the number of access points that need to be deployed for optimal deep indoor coverage, impacting the total cost of ownership, which translates in higher subscription pricing. A third element here is the capacity of a network, how much data can be handled by the same infrastructure. Obviously, a water meter might only need one message per day however a tracking solution will require updates every couple of minutes thus consuming much more bandwidth, so capacity should be expressed in terms of throughput and not sensors. The more cost effective a solution will be, keeping in mind unlicensed technologies do not suffer from high license cost, they should be in a favorable position to address use cases with very challenging return on investments.

A last important aspect is the fact that unlicensed technologies can be deployed by anyone allowing Cities or incumbents to build public or private networks.

In order to classify the unlicensed access technologies addressing IoT these are divided here based on their typical transmission range, from short range to medium range and long-range technologies.

**Short Range**

The wireless access technologies in this category have traditionally been used for Personal Area Networks (PANs). However, mesh capability has enabled them to expand their coverage area significantly by multi-hopping. Growth in this category is reported as being driven by consumer electronics, home automation, smart city and smart buildings.

***IEEE 802.15.4***

IEEE 802.15.4 is the MAC and PHY standard operating primarily in 2.4.GHz ISM band, targeted for low power and low rate PAN applications. It is the basis for ZigBee, and hhread specifications, among others; these specifications specify the upper layer functionalities.

***Bluetooth***

Another low rate PAN technology operating in 2.4GHz ISM band is Bluetooth. While traditionally it has been used for audio applications, Bluetooth Low Energy (BLE) has been introduced to expand into IOT applications including healthcare and home entertainment. To further improve the applicability and use of Bluetooth technology, the Bluetooth SIG is in process of definition of a long-range version of Bluetooth as well as enabling Bluetooth mesh.

***Zwave***

Designed to provide reliable, low latency, and low data rate communication, Zwave's target application is home automation. It operates in sub 1GHz ISM band. Similar to the previously listed PAN technologies, Zwave can also be used to cover a larger area by use of mesh although the complexity of large scale mesh networks, including the relatively high number of gateways and repeaters, typically result in implementations focused on small geographical areas.

***IEEE 802.11ad (WiGig)***

Operating in 60GHz ISM band WiGig enables communication at very high data rates. Given that the 60GHz signal typically cannot penetrate through walls, the WiGig network is confined to a room. The large channel bandwidth of WiGig enables delivery of signals at a very low latency, making it a good candidate for mission critical industrial applications.

**Medium Range**

Wi-Fi is the only medium range wireless technology capable of providing single hop connectivity in a local Area Network (LAN). Other technologies like Wi-Fi HaLow and 802.11p provides narrowband connectivity to IoT applications based on 802.11 spectrum bands.

***Wi-Fi***

The traditional Wi-Fi operates in 2.4GHz and 5GHz ISM bands and comes in two flavours of Infrastructure Wi-Fi where devices connect to the Access Points (APs) primarily for accessing the internet and Wi-Fi Direct which enables peer-to-peer communication among devices without need of an AP.

***Wi-Fi HaLow***

Wi-Fi HaLow, which is currently under development in the Wi-Fi Alliance, operates in sub 1GHz ISM band. Wi-Fi HaLow is based on IEEE 802.11ah which provides longer range, lower power operation, and lower throughput compared to other Wi-Fi technologies and hence is suitable for sensors and IOT devices distributed in larger areas. Non-harmonized spectrum is globally identified as a contributing factor for slow adoption of Wi-Fi HaLow in the industry.

***IEEE 802.11p***

IEEE 802.11p defines enhancements to Wi-Fi required to support Intelligent Transportation Systems (ITS). IEEE 802.11p operates in 5.9GHz band. IEEE 802.11p enables delivery of high throughput data with low latency which is required for ITS safety applications.

**Long Range**

The Low Power Wide Area Networks (LPWAN) operating in unlicensed bands primarily target IOT applications.
These technologies are also managed and are mostly complementary with their licensed counterparts, i.e., Cellular IOT solutions which are typically higher cost (Bill of Material and Simcard) as well as a magnitude higher power consumption on the sensor side. More over unlicensed technologies provide the option for Cities or other incumbents to build their own access network, or have service providers such as MachineQ (Comcast) deploy and manage them, without being dependent on the cellular industry. Due to the attractiveness of LPWA cellular operators around the world are also deploying for example LoRaWAN networks in conjunction with Cellular IoT in order to be able to address the majority of use cases.

***LoRaWAN*:**

The LoRa Alliance is driving the adoption of the open standard LoRAWAN protocol that has been optimized for low cost, low power, battery powered IoT devices that leverage Semtech's LoRa® Chirp Spread Spectrum based physical layer. LoRa enables deep indoor, secure encrypted, bi-directional communication, geolocation and firmware over the air updates, addressing most of the IoT use cases, especially those operating on batteries. With over 500 members the LoRa Alliance has the largest and fastest growing global eco-system including sensor certification programs to ensure interoperability and performance. LoRaWAN is deployed in more than 100 countries around the world both in public and private networks and already serves many connected cities with for example parking, streetlight, environmental monitoring and building management solutions.

***SigFox:***

Sigfox is deploying, in some countries with partners, open networks using proprietary gateways and a centralized proprietary cloud service which communicates with sensors using an Ultra Narrow Band physical layer. The Sigfox solution is designed for infrequent sending of very small 12 byte messages with very limited downlink requirements addressing a subset of IoT use cases. Sigfox expects its solution providers to implement security as the protocol does not include embedded encryption

***Wi-SUN:***

The Wi-SUN Alliance promotes open interoperable standards for Smart Utility Networks based on peer-to-peer and wireless mesh based IEEE 802.15.4g networks.

### 5.6.2 Alternative Licensed Access Technologies

The licensed access technologies addressing IOT are identified here. These technologies operate by sharing spectrum with LTE and GSM networks that provide other data and voice services.

***LTE-M***

Standardized by 3GPP LTE M is an evolution of LTE, optimized for IoT, which can be deployed over an existing LTE infrastructure.LTE M is aiming at applications which require higher throughput, when compared to LoRaWAN and NB IoT for example, and typically sensors will need external power

sources given the power consumption characteristics. As this technology is currently being rolled out by cellular operators the "sweet spot" use cases will have to be proven going forward

***Narrowband IoT (NB - IoT)***

Standardized by 3GPP can be deployed over an existing infrastructure, with potential hardware updates, of a normal LTE carrier and can also be used "standalone" to enable deployments in dedicated spectrum. The intended focus of this technology is on use cases which require indoor coverage, cost effective sensors, long battery life and a large number of devices. Given the developing eco system around NB IoT and the currently limited coverage there are mainly proof of concepts and expectation is that it will serve complementary use cases, when compared to for example LoRaWAN, which require strict SLA's and can afford the additional cost.

***EC-GSM-IoT***

Standardization in place by 3GPP, expected to be concluded by the end of 2016. It is an evolution of GSM (eGPRS/EDGE) optimized for IoT, designed as a high capacity, long range, low energy and low complexity cellular system for IoT.

### 5.6.3 Mapping of alternative access technologies to IoT Requirements

The applicability of different access technologies to different applications is determined by the application's requirements and the ability of the access technologies in addressing those. The following are the main requirements of IoT applications.

- **Coverage**

Some IOT applications, e.g., Industrial applications, require a wide coverage area, whereas home applications, for example, require a small coverage area. A large coverage can be provided by use of multi-hopping, a technique ZigBee utilizes to extend its coverage area; or can be achieved by longer range transmissions, as provided by Wi-Fi for medium range coverage or LP-WAN technologies for wide area coverage.

- **Scalability**

The ability of an access technology to scale to a large number of nodes with high efficiency is another determining factor for its applicability for a particular application. Bluetooth for example, is capable of supporting small-sized networks, whereas ZigBee easily scales to very large networks and LPWAN technologies like LoRa scale almost infinitely given the network topology.

- **Power**

A major requirement for IoT sensors is low power operation and a multi-year-long battery life. There are other IoT devices, for example in Industrial applications, which are ac-powered. And there are different devices with different battery life expectancies in between. A related parameter to power is the form factor; the form factor of a battery powered device determines the type and size of battery it contains and hence how low power the operation of the device needs to be. Other related parameters impacting power requirements are required throughput and traffic patterns, battery cost as IoT solutions are very ROI sensitive, as well as the determinism of access.

***Throughput and traffic patterns***

While sensors typically require very low throughput to transmit collected data at low frequencies, e.g., reporting measured temperature every hour, other IoT devices, for example surveillance cameras, require higher throughput for long durations of time. There are actuators that typically only receive data and there are sensors which only report data, and there are many different types of devices that both transmit and receive on a regular basis. Another important aspect is Firmware or Application updates over the air as the sensors typically in the field for a very long time and may require the ability to be upgraded.

- **Reliability**

Some applications require high reliability communications. All wireless access technologies that operate within a fading environment provide probabilistic reliability, i.e., there will typically always be a finite possibility that the wireless channel is suffering from an extreme fade. Furthermore, wireless access technologies that operate in unlicensed spectrum needs to operate in an environment with un-coordinated and un-controlled sources of interference and hence inherently cannot provide guaranteed reliability; however, higher levels of reliability is achievable with implementing efficient medium access mechanisms and operation in low interference environment.

- **Determinism**

Mission critical applications require determinism to be provided by the access technologies. While unlicensed technologies in general do not provide guaranteed timely access to the wireless medium, in special scenarios, for example in an isolated industrial field, determinism can be achieved especially for short-range and high-bandwidth communication technologies like WiGig.

- **Cost**

Unlicensed communication technologies enjoy lower cost in general compared to cellular communications. Among unlicensed technologies the cost the complexity of the technology and the size of the existing ecosystem impacts the cost

- **Security**

Secure communication is required for many IOT applications and becomes more critical for longer range access technologies. In principal, all over the air data should be encrypted and the security key management (trusted third party) should be an integral part of the offering (see also section 5.6.)

| Access Technologies | Requirements | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Coverage | Scalability | Power | Throughput | Reliability | Determinism | Cost | Security |
| **IEEE 802.15.4** | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| **BT&BLE** | ✗ | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| **ZWave** | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| **WiGig** | ✓ | ✓ | ✗ | ✓✓ | ✓ | ✓ | ✗ | ✓ |
| **Wi-Fi** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| **Wi-Fi Halow** | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| **LP-WAN** | ✓✓ | ✓ | ✓✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| **LTE-M** | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ |
| **Narrowband IoT (NB-IoT)** | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ |
| **EC-GSM-IoT** | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ |

**Table 5-.2.3: Mapping of Access Technologies to IoT Requirements**

## 5.7 Security. Needs, Concerns and Challenges

With projections of billions of connected devices by 2020, the challenges facing the Internet of Things (IoT) include a lack of standardization, security, integration, battery life, and rapid evolution. Wi-Fi, is getting ready for IoT and will perhaps make one the most suitable network for the technology.

Some of the challenges facing the IoT, and how Wi-Fi can help address them:

- IoT ideally needs a standardized technology for connecting devices to each other or the cloud
- The things (as in IoT) typically employ some kind of embedded technology that allows them to sense conditions such as pressure, humidity, temperature, motion, number of people in an area, etc. Then a technology allows them to connect to other things or the cloud so that they can send the information as well as be programmed.
- There are many standards and proprietary solutions used for connecting things to each other or to the cloud:
  - Wi-Fi, Bluetooth, ZigBee, Active RFID, loWPAN, EtherCAT, NFC, RFID to name a few.
- The choice of technology is usually dictated by the physical characteristics of the environment, such as the presence of wood, concrete, metal etc., the density of sensors, desired range, and data rates.

Among these technologies, Wi-Fi has been the most successful. It has become a ubiquitous standard of connectivity and is used in the home, enterprise, schools, hospitals, airports etc.

The number of devices connected to a Wi-Fi Access Point or the distance of device to Access Point is limited, many Active RFID technologies that operate in sub 1-GHz bands are used for things too. Active RFID technologies allow a large number of devices as well as larger ranges.

To overcome these challenges the IEEE Wi-Fi standard 802.11ah using the 900MHz band has been in works and will solve the need of connectivity for a large number of things over long distances. A typical 802.11ah access point could associate more than 8,000 devices within a range of 1 km, making it ideal for areas with a high concentration of things.

Standardization and implied interoperability is one of the main reasons Wi-Fi is very popular, which is why it is suitable for many IoT projects.

Needs of **security** and protecting privacy in the borderless world created by IoT are real IoT creates a borderless world where things talk to the cloud. Network or device administrators may not even realize the firmware or operating systems of these things or the cloud applications that these things talk to. In other words, protecting privacy and preventing malicious activity will be a challenge.

While IoT may be a game changer for Connected Cities in many respects, from a security perspective the game changes little. At its most basic level, security for the Internet of Things depends on our ability to identify devices and their masters, and protect the data that those devices and masters manage and share.

When connecting the physical world with the digital world it is obvious all players in the value chain will need to work towards an intrinsically secure Internet of Things. Security breaches of individual sensors is one thing, however attacks on groups of sensors or even the infrastructure as a whole is where vulnerabilities must be taken care of from the design stage and risks must be identified and eliminated. When discussing security, a zero tolerance approach is recommended and monitoring mechanisms should be put in place to detect and protect against breaches whenever they occur.

As IoT is attracting a lot of new players which may or may not have sufficient knowledge about data security it is adamant the suppliers of the technology embed in their standards mandatory mechanisms to ensure optimal data protection as well as overall integrity of the data, both coming from the sensors as well as being send to the sensors.

The challenge in IoT is to drive optimal security whilst cost remain acceptable and usability is not impacted: Especially when deploying millions of sensors, certainly in consumer markers on the longer run, an out of the box automatic provisioning with highly secure processes for exchanging security keys is a must.

When looking at cellular technologies the required security is managed through the use of sim cards, however for non-cellular technologies other means must be put in place. Thus, secure elements in each sensor with the option to use a trusted third party for security key management are needed and short cuts must be avoided. Also, the air interface should be clearly encrypted to protect the end user's data as well as protection mechanisms against spoofing:

Providing greater insight and control over elements in our increasingly connected lives, the Internet of Things (IoT) emerges at a time when threats to our data and systems have never been greater.

As new connected devices come to market, security researchers have taken up the cause to expose their vulnerabilities, and make the world aware of the potential harm of connecting devices without proper security.

An example of "security by design" for LPWAN's is represented in the table below.

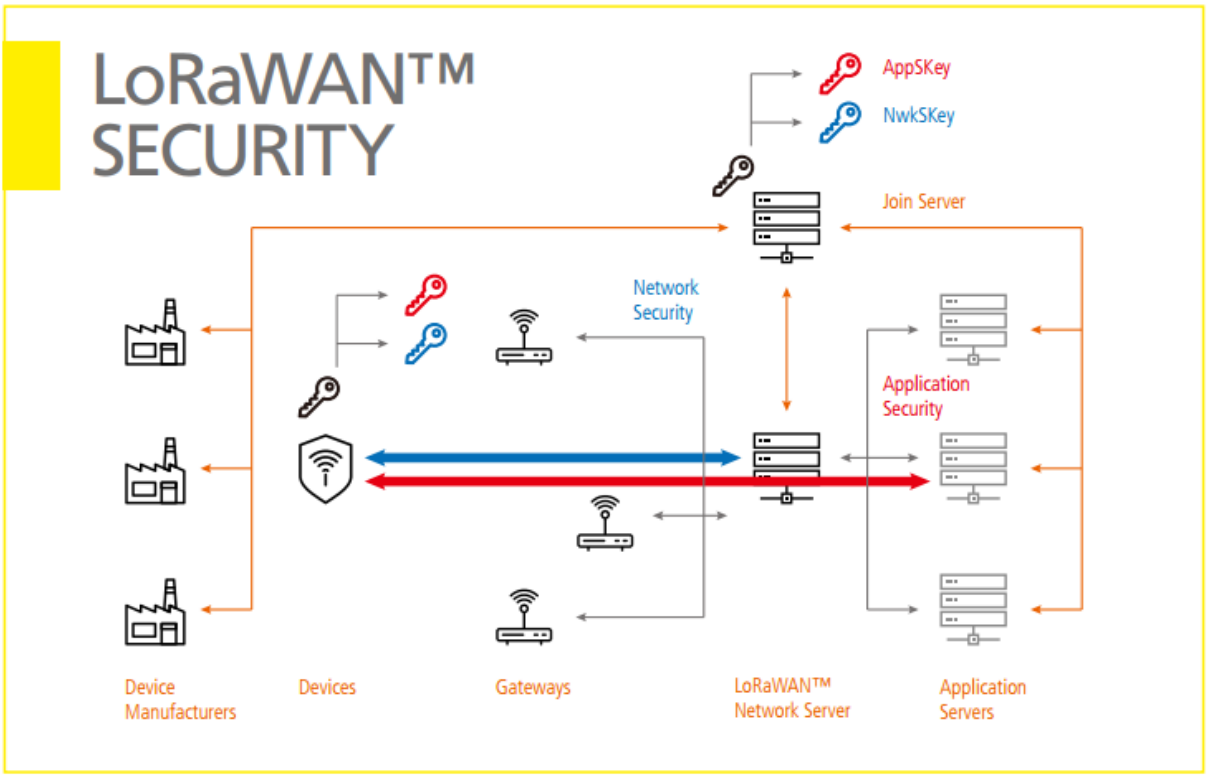



**Figure 13: security by design" for LPWAN's**

All traffic is protected using two session keys. Each payload is encrypted by AES-CTR and carries a frame counter (to avoid packet replay) and a Message Integrity Code (MIC) computed with an AES-CMAC (to avoid packet tampering). The server managing the key storage for mutual authentication and key derivation can be run by a trusted third party to make sure the Connected City's data is not accessible by the network operator.

To leverage the true potential of IoT many Connected Cities have started trials and initial roll outs however it is clear on the longer run 5G networks will play a significant role.

5G systems are the next step in the evolution of mobile communication and will be a fundamental enabler for the Connected Cities. 5G tends to be a multi-layered, multi-player, and multi-access mobile network. In order to fulfil the stringent availability, security, privacy and resilience requirements are often contradictory. This development creates new security scenarios and requires new security solutions.

Security services such as encryption for wide public usage were pioneered in GSM system design before evolving further in 3G and 4G. While these services have worked well in safeguarding trust in today's vast communications ecosystem, 5G will drive completely new requirements.

5G security will be defined not only by quantitative aspects such as bitrates and latency, but more importantly by qualitative aspects such as new business and trust models, new ways of delivering services, an evolving and threatening landscape and an increased concern for privacy.

This now drives a need for a fundamentally new, multi-player trust model that allows more flexibility. Security for virtualized networks and services should be considered. Attack-resistance and data security must represent basic design criteria for new protocols, while security assurance and compliance have to be more verifiable and measurable. Tackling these challenges will require new tools such as network slicing, trusted computing and alternative ways of handling user identities.

**Four key areas for 5G networking to review:**

1. Massive IoT,
2. Critical Communications,
3. Enhanced Mobile Broadband
4. Network Operations (which underpins the three other areas).

Across these segments, security requirements will vary, both at the network access level and at the service level, where demands may range from those posed by low level sensors to those of high-end use cases like real-time remote controls, driverless mobility and remote surgery.

Needs will differ around how frequently communication occurs, the amount of data to be managed and communicated, speed and latency and around how frequent authentication has to be.

For example, critical communications will require much more frequent authentication than IoT and will involve far more sensitive data. Conversely, massive IoT will provide a scenario where devices will communicate infrequently, use low power and may require extended lifespans. In enhanced mobile broadband and in critical communications, performance demands may open the way to enhanced and highly efficient security mechanisms.

Changes in the business aspect of the 5G ecosystem and other technological developments, some likely, others hypothetical such as the possible arrival of quantum computing, will also combine to add to the complexity of the security challenges.

5G and its development is of considerable interest to government, standardization bodies, industry manufacturers, including OEMs and chipset manufacturers and designers, telecommunications operators, service providers, application providers, operating system providers, SMEs and researchers, amongst others. Significant actors in the ecosystem will include:

- 3GPP, which unites seven telecommunications standards bodies ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC and will develop the dominant standard

- NGMN, a grouping of leading operators, vendors and universities
- GSMA, the industry body of mobile operators
- Regional bodies such as 5G-PPP, a public private partnership initiated by the European Commission involving operators, vendors, service providers and universities
- Other standardization or industry bodies such as one M2M, IEEE, IETF. Wi-Fi Alliance
- Manufacturers
- Regulatory bodies around the Globe

All of these bodies are likely to have an input into the eventual technical definition of 5G standards

According to the demands of the segment, a broad range of security solutions or changes in feature sets of those solutions are likely to be needed much is yet to be determined, including the need for backward compatibility with earlier generations of communications

## 6 The Increasing Relevance of Cities and Use Cases identification and examples

Some of the key numbers driving the importance of cities needs to become Smart. Connectivity in Cities, at its core, is a civilization changer on the same level as roadways, water systems and electric grids

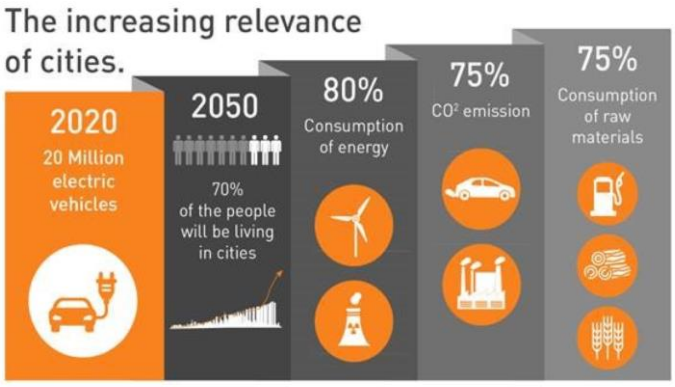



**Figure 14: Infographic - Smart Solutions for Smart Cities**

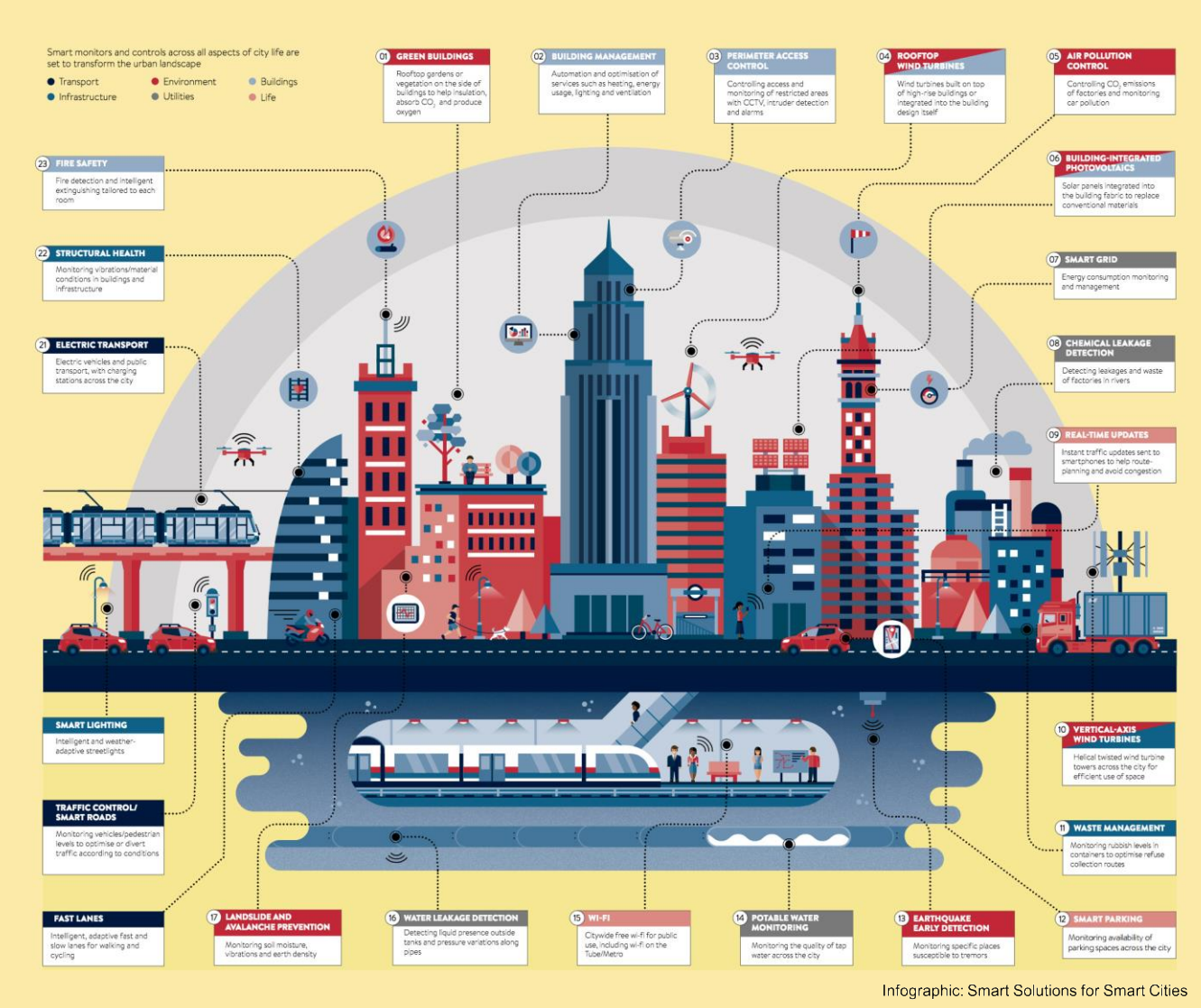



**Figure 15: A city consists of a combination of cases spread across several vertical service categories**

The diagram above gives an overview of the different smart city cases that can be rolled out. A city does not have to adopt every service to be considered smart, but normally are linked by a common infrastructure, platform and technology.

## 6.1 Milton Keynes UK Autodrive Self Driving Pods Trial

**NOVEMBER 2015 UK Autodrive gets underway.**

The UK Autodrive project got underway on 1st November 2015, marking the start of an ambitious three-year trial of connected and autonomous vehicle technology.

One of three projects to have emerged successfully from the UK government's 'Introducing Driverless Cars' competition, UK Autodrive will carry out on-road trials in Milton Keynes and Coventry, using cars provided by project partners Ford, Jaguar Land Rover and Tata Motors European Technical Centre. The

programme will also trial a fleet of lightweight, self-driving 'pods' for use on pavements and other pedestrianised areas.

The project will run for three years (until October 2018) with several major milestones along the way, including the start of the vehicle trials – the first of which took place at the HORIBA MIRA Proving Ground in October 2016. In the last year of the programme, autonomous and connected cars and pods will become a regular sight in Milton Keynes and Coventry.

This collaboration with global partners continues to push the thinking on the delivery of autonomous transport within the city and on a city to city scale. Milton Keynes Council has brought together leading automotive partners such as JLR and British engineering firm RDM to build a reality for the deployment of autonomous pods on the streets of MK including in 2108 a test of a new transport service through a fleet of 40 fully autonomous pods that will serve as a "last mile" transport solution in the city centre

Self-Driving Pods


View More Information about Self-Driving Pods

The trials will:

1) Integrate autonomous and connected vehicles into real-world urban environments.
2) Show how autonomous and connected vehicles could solve everyday challenges such as congestion.
3) Demonstrate the commercial operation of electric-powered self-driving "pods" at a city scale.
4) Provide insight for key stakeholders and decision-makers, including legislators, insurers and investors.

Milton Keynes is the fastest growing city in the UK and an economic success story. Through the MK Futures 2050 vision process that engaged thousands of local citizens, the city has created a growth strategy that will take its population from 270,000 today to over 400,000.

The challenge is supporting sustainable growth without exceeding the capacity of the infrastructure, whilst also meeting key carbon reduction targets. Addressing these challenges and ensuring inclusive growth and a quality of life provides some of the main drivers for the continuing innovative smart city projects in MK.

The city vision has always been one of innovation. As a new city created only in 1967, Milton Keynes was planned to be "different by design," and in recent years has built on the tradition of innovation set by the nearby Bletchley Park, the birthplace of modern computing, to becoming a pioneer in the use of Big Data, transport innovation and urban design.

MK Council benefits from senior leadership and commitment to its smart city programme. The Leader of the Council, Cllr Peter Marland, has a national profile for smart city leadership and works with the council's Director of Strategy and Futures, the Head of Transport Innovation and the Head of Economy and Culture to ensure that the MK vision as a leading UK city is planned and delivered in an agile way. MK Council has bolstered this leadership with senior stakeholders from Higher Education and business to ensure both intellectual and commercial vision and application is based on a broad church.

MK Council brought together a consortium of partners in 2013 to better understand the landscape of Smart City Innovation and to build a comprehensive map of all existing and proposed local initiatives that could collectively deliver to the Smart City agenda. This activity was the birth of the MK Future City Programme under the leadership of an executive of MK Council, The Open University and BT. The programme has grown to include global industrial partners like ZTE, JLR, Samsung, Huawei, Tech Mahindra and a vast array of small and medium sized local business; community action groups and the citizens of Milton Keynes.

MK benefits hugely from the structure and agile delivery of its leading city partnerships that have delivered and will continue to deliver a ground-breaking smart city environment that combines technology innovation with business and citizen engagement.

MK: Smart has been a signature project for the city, demonstrating the power of data at the heart of a city to deliver innovation in multiple domains with a broad range of stakeholders.

MK maintains a UK-leading position in Intelligent Mobility. MK Council's Head of Transport Innovation works closely with government agencies such as the Transport Systems Catapult and with corporates such as Jaguar Land Rover, Tata and Ford to design and lead on a programme that includes the city-wide adoption of electric buses, autonomous vehicles for last mile journeys, significant investment in Electric Vehicle charging infrastructure and promotion programmes.

**Connected Vehicles (CVs) (also can be known as Cooperative Intelligent Transport Systems (C-ITS)):** CVs refer to vehicles with increasing levels of connectivity which allows them to communicate with their surrounding environment (including the infrastructure and other vehicles). This could provide information to the driver about road, traffic, and weather conditions, and on routing options and enable a wide range of connectivity services. It could be argued that the term CV refers to a broader set of applications than C-ITS (including in car entertainment) so the two terms are not necessarily interchangeable but are closely related.

**Automated Vehicles (AVs) (also known as autonomous, self-driving or driverless vehicles):** Vehicles with increasing levels of automation will use information from onboard sensors and systems to understand their location in relation to their environment and navigate through it with little or no human input for some, or all, of the journey. Road based vehicles are predominantly considered within this report.

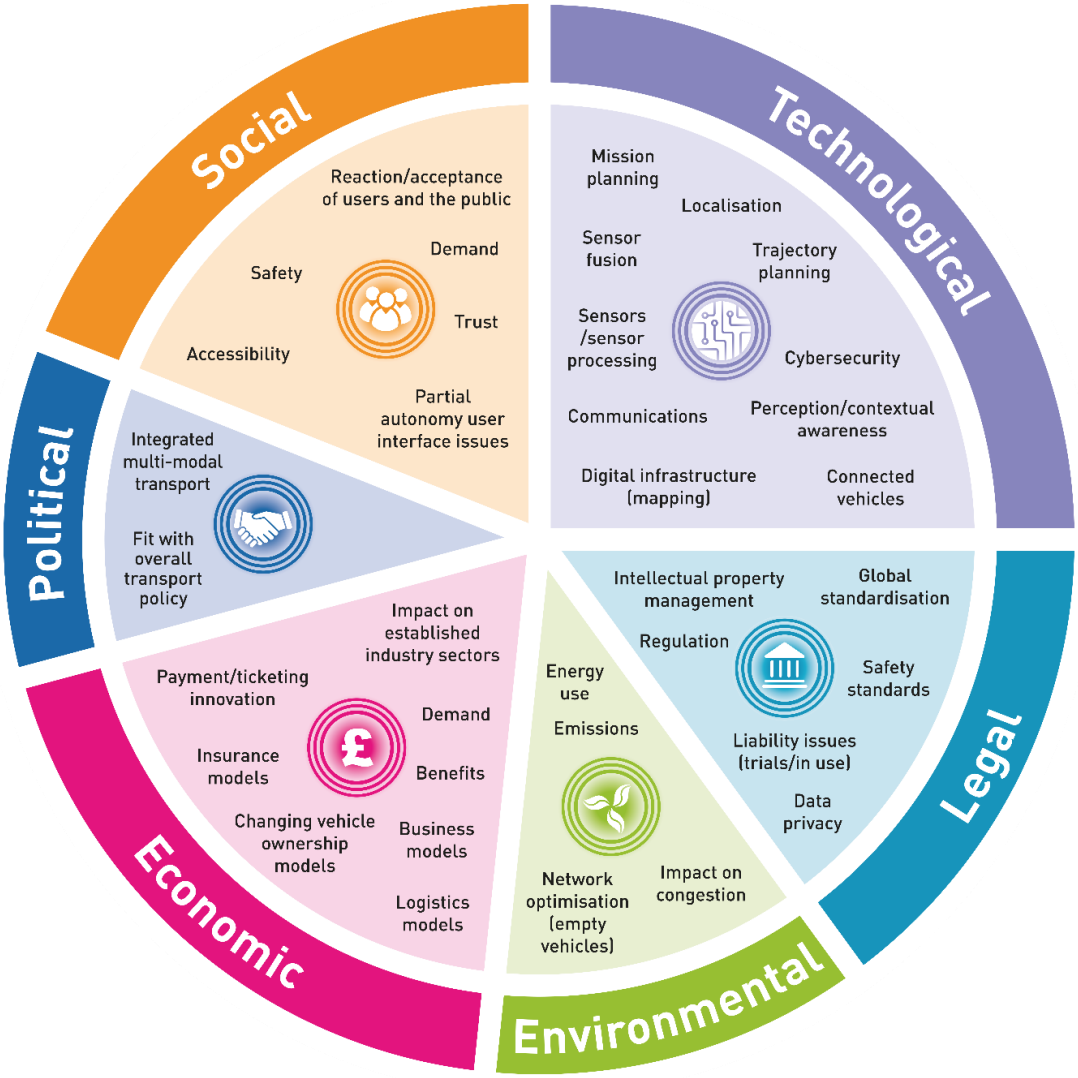



**Figure 16: CAV Areas of Interest**

Some of the potential benefits are subject to debate and yet to be proven or quantified. However, CAVs certainly have the potential to release driver time for other uses and improve mobility for those that don't drive, so these two aspects alone are sufficient reasons to be optimistic about their introduction.


Figure 17: Motivations for CAV Introduction

**How the programme is funded**

UK Autodrive is the largest of three separate consortia that are currently trialing automated vehicle systems as part of the government's "Introducing driverless cars to UK roads" competition. The project is jointly funded by government and industry, and delivered by the UK's innovation agency, Innovate UK, with the total investment adding up to approximately £19.4 million. For more on the two other consortia taking part in the competition, see the Venturer and GATEway website


Figure 18: The vehicles

**Connected road-based passenger cars**

UK Autodrive's connected car trials will examine the potential benefits (in terms of safety, traffic flow and the environment) of having cars that can "talk to each other".

Ford, Jaguar Land Rover and Tata Motors European Technical Centre will all be providing vehicles for these collaborative trials, which are due to take place initially on the HORIBA-MIRA test track in Nuneaton before moving on to closed city streets in Coventry and Milton Keynes and then on to open roads.


**Autonomous road-based passenger cars**

Jaguar Land Rover and Tata Motors European Technical Centre will also be using the UK Autodrive programme to trial autonomous (self-driving) cars.

As with the connected car trials, the autonomous trials will begin on the HORIBA-MIRA test track before moving through progressively complex urban scenarios. Trained operators will remain at the wheel of each vehicle for the duration of the trials, ready to take control if required.


**Figure 19: Connected and autonomous pavement-based 'pods'**

As well as trailing 'regular' road-based cars, UK Autodrive will also trial a fleet of up to 40 self-driving 'pods' that can operate on pavements and other pedestrianised areas. Designed and built by Coventry-based firm RDM Group, the electric-powered vehicles will be used to test the feasibility of using low-speed autonomous transport systems to help move people within towns and cities.

During the early stages of the trial, trained operators will be sat in each pod. Later on, it is planned that invited members of the public will be able to call up and use the pods in a small-scale public trial of the technology.

**MAY 2016 First UK Autodrive white papers published**

Alongside the physical trials of connected and autonomous vehicles, UK Autodrive is contributing a considerable body of research aimed at supporting the government's stated ambition of establishing the UK as a global hub for the development of autonomous vehicle technologies.

During the course of the three-year programme, consortium members Gowling WLG and AXA will be publishing a series of white papers on the legal- and insurance-related issues affecting the technology. The first of these (on data protection) was published in May 2016 followed, in December 2016, by a report into the 'moral algorithms' that may be used to determine how self-driving vehicles behave.

Download your copy of the "Are You Data Driven?" and "Moral Algorithm" reports

Download the Reports 

**OCTOBER 2016**

- First public attitudes survey
- UK Autodrive's Cities Research programme will examine a number of areas related to the wider roll-out of connected and autonomous vehicles, using research teams from the Universities of Cambridge and Oxford.
- One strand of this research programme will look at public attitudes to self-driving vehicle technology, via a series of national workshops and online global surveys, the first of which was **sent out in October 2016**.
- Other areas of study will examine the business case for self-driving 'pod' vehicles, how the technology can be scaled up, and how the eventual mass roll-out of autonomous and connected vehicles could affect congestion levels.

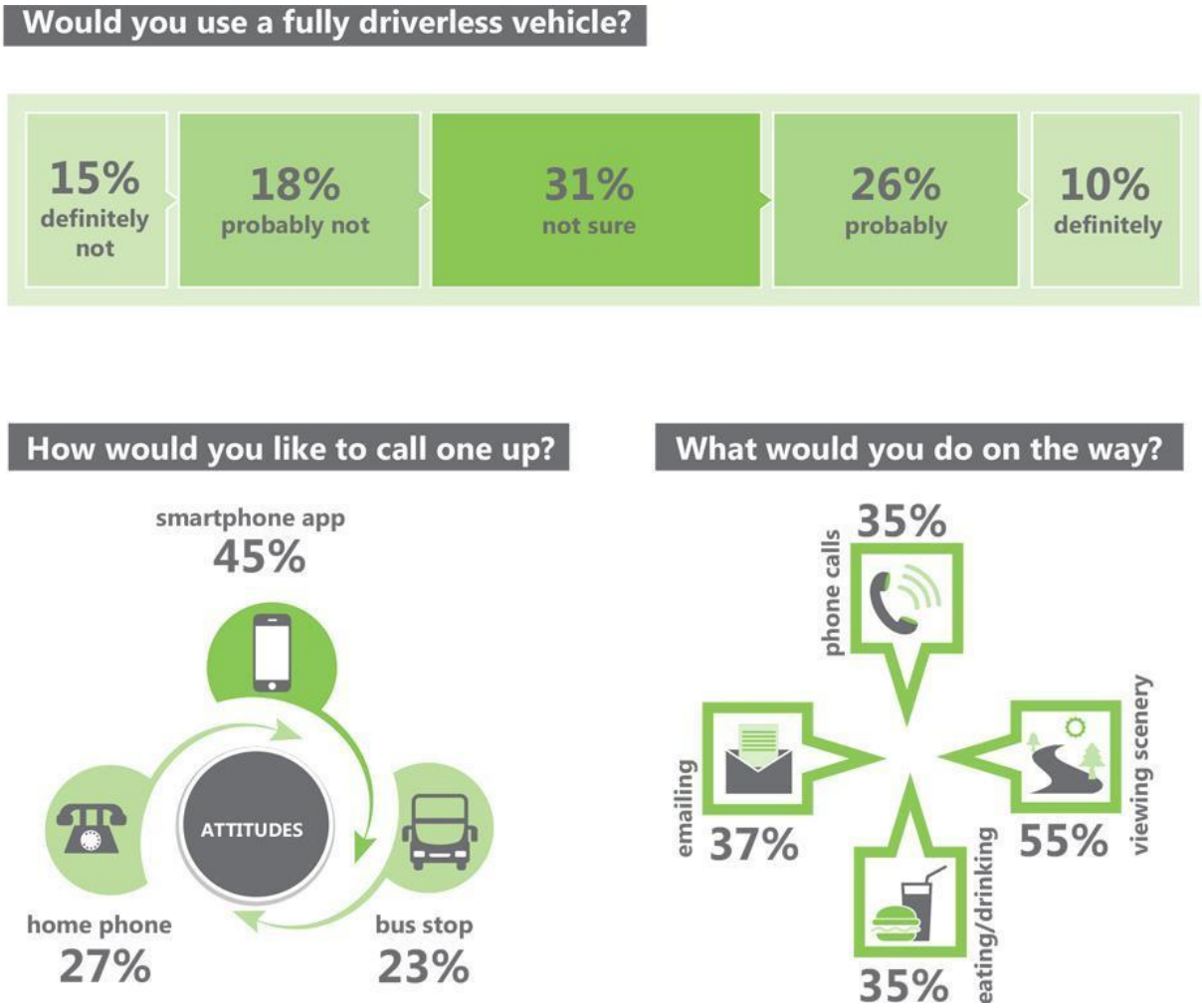



**Figure 20: Self-Driving Vehicle Survey**

The Cambridge University survey was completed by 2,850 UK residents

People living in the UK are highly familiar with the concept of "driverless cars", but have not yet formed hardened opinions about the technology, according to a nationwide survey carried out on behalf of the UK Autodrive programme.

Conducted by researchers at Cambridge University's Engineering Department and the Department of Psychology, the online survey was completed by 2,850 UK residents.

It found that more than three quarters (76%) of those surveyed had heard of driverless vehicles, comparing favorably to driver assistance technologies that are already commercially available, such as adaptive cruise control (familiar to 40% of those surveyed), automated emergency braking (38%) and lane-keeping systems (34%).

While general levels of awareness are high, it appears however that the technology has not yet been around long enough for hard-line attitudes to set in. The responses revealed a remarkably open mind to the arrival of self-driving vehicles, with 35% of those surveyed saying they would use a fully self-driving

vehicle (without a driver or steering wheel) once one was available to them. Only 15% of the respondents expressed strong opposition to the idea.

- Head to UKAutodrive's **Downloads** section for an Executive Summary and Infographic of the survey's main findings


Nevertheless, some reticence was expressed when it came to the ability of new technology to replace human involvement completely. In response to questions about what levels of control they would like to retain, 85% expressed a desire to retain some control over the choice of route, and 74% wanted to retain an option to drive manually.

The 49-question survey also asked people what they would do while riding in a self-driving vehicle, with more than half (55%) saying they would look out at the scenery. Checking emails (37%), making phone calls (35%) and eating or drinking (also 35%) were among the other popular choices.

**Useful for shopping**

There was also a wide range of views expressed in terms of when people would want to use a self-driving vehicle, with 23% of respondents saying that they would most use one for shopping excursions, followed by commuting (22%), social/leisure travel (22%), and a sizeable 15% who would be mainly interested in using self-driving vehicles after drinking alcohol.
When asked how they would like to summon a self-driving vehicle if using one as a form of public transport, 45% of respondents said they would like to use a smartphone app, though calling one up from home (27%) or catching one at a bus stop (23%) were also popular options.

A large majority (80%) of those surveyed felt that self-driving vehicles would assist people with impairments or disabilities, but the results were far more varied when it came to such vehicles being used by other members of the public.

**School run skepticism**

Just over a third (36%) said they would recommend self-driving vehicles to people of a similar age and lifestyle to themselves, while 42% said they would recommend them for their parents or older loved ones. When asked if they would send their children to school in a self-driving vehicle, however, only 19% of those who responded said they would do so, with 59% either opposed or strongly opposed to the idea.

"The survey results give some fascinating insights into what the UK public currently think about self-driving vehicles, and we will continue to dig deeper into this as the UK Autodrive project continues," said UK Autodrive Project Director Tim Armitage.

"For a technology that is not yet commercially available, it is striking that so many people have already heard about self-driving vehicles," added Pat Langdon, Principal Research Associate at the University of Cambridge Engineering Design Centre. "There is obviously still plenty to be done in terms of educating the public – particularly when it comes to the potential benefits this technology could bring – but there is already lots of positivity in these initial findings."

Following on from the first wave of public attitudes research, UK Autodrive will now stage a series of qualitative workshops in locations across the UK to further explore the reasons behind some of the opinions expressed and to investigate ways in which attitudes towards self-driving vehicle technology might be further improved in the future.

A second nationwide survey will also be conducted towards the end of the UK Autodrive project to measure any changes in attitude that may have occurred.

**JUNE 2017 Completion of proving ground trials**

The second (and final) set of private test track trials took place at HORIBA MIRA in June 2017 and again saw connected car technology being collaboratively demonstrated by Ford, Jaguar Land Rover and Tata Motors European Technical Centre (this time including an Emergency Vehicle Warning, Intersection Collision Warning and In-Vehicle Signage feature), along with an Autonomous Urban Drive demonstration by Jaguar Land Rover.

**AUTUMN 2017 Start of self-driving pod field trials**

As well as trialing connected and autonomous technology on 'regular' road-based cars, UK Autodrive will trial a fleet of electric-powered 'pod' vehicles specifically designed for use on pavements and other pedestrianised areas.

These self-driving pods are intended to offer 'last mile' services, for example taking passengers from a train station or 'Park and Ride' facility and on to their final destination.

Up to 40 pods will be used to test the feasibility of operating an on-demand form of public transport, with field trials due to get underway in the autumn of 2017.

**AUTUMN 2017 Connected and autonomous car demonstrations; pod demonstrations**

As UK Autodrive moves into its final year, a further set of demonstrations are planned in the host cities for both the road-based cars and the pavement-based pods.

The cars will demonstrate another set of potential uses for connected and autonomous vehicle technology, while the pods will be used to showcase the benefits of 'last mile' on-demand transport.

**SUMMER 2018 Publication of safety, security & communications reports**

An important aspect of UK Autodrive is a specific work package examining the safety, security and communications requirements for connected and autonomous vehicles.

Led by HORIBA-MIRA, this work package will initially focus on supporting these requirements for the UK Autodrive vehicle trials themselves. As UK Autodrive comes to the end of its three years, the work package will culminate in a series of guidance papers for managing safety, security and communications in future deployments of automated vehicles.

**SUMMER 2018 Final public demonstrations**

The UK Autodrive trials will culminate in a final set of demonstrations and public engagement activities in Milton Keynes and Coventry during the summer of 2018, using both the road-based cars and pavement-based pods to showcase the potential benefits of connected and self-driving vehicles.

**AUTUMN 2018 Publication of final project reports**

UK Autodrive will culminate in a series of reports, including the final project report, final legal and insurance white papers and the final research papers from the Cities Research programme (examining changes in public attitudes towards the technology, the scalability of self-driving vehicle technology and the possible effect that self-driving vehicles might have on congestion levels).

As well as looking back on the learnings of UK Autodrive, these reports are intended to provide guidance and direction for future research and development as connected and autonomous vehicles move closer to the mainstream.

**Potential Outcomes**

There are many scenarios that could play out but there are two clear use cases that could have significant impact on MK's wider rail transport plans:

- Automated valet parking
- Automated public transport vehicles

Auto-valet parking could help to relocate parking from areas of high parking demand to areas of low demand.

There is potential of auto-valet parking to increase supply of parking with vehicles parking more efficiently. It is recommended that real-world trials of this technology continue as this could be particularly beneficial at railway stations where demand often exceeds supply.

Generally, until the technology is more mature and intelligent, automated public transport vehicles will need dedicated pick-up and drop off areas.

In the early years, these vehicles will need to co-exist with traditional forms of public transport road vehicles, such as buses, taxis and private hire vehicles.

There is already competition for road space around railway stations, and there may be opposition to relocating conventional modes of transport to create pick up and drop off areas for AVs. There may be difficult choices ahead about how to allocate space around station entrances, and this should be discussed in the planning of any future station designs.

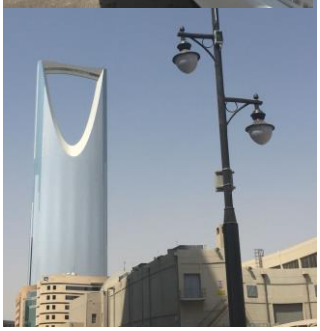
## 6.2 Riyadh, Saudi Arabia: IoT. Smart Parking Management System


In June 2017, the city of Riyadh started the first phase of a pilot project to deploy 1,500 smart parking sensors and 10 information panels, all based on LoRa communications.

The city of Riyadh is a point of reference for Smart Cities in the Middle East. The smart parking pilot was deployed in one neighborhood of the capital to evaluate the benefits of this technology. Riyadh is planning to expand smart parking technology to other neighborhoods in the coming year.

The smart parking pilot is part of an overall Smart City framework provided by technology giant CISCO. The local entities involved in the project have been:

- Worldsensing: Technology provider
- Qaxis: Parking expert
- CISCO: Technology provider
- BTC: System Integrator
- STC: Telecom Operator



The technologies being used and tested are the Parking Management System Fastprk and LoRa.

The overall project was initiated by the city and was taken on by the local consortium between BTC, CISCO and STC. The project is being funded by the city of Riyadh.
The key objective of this Use Case is to optimize traffic flow in the city of Riyadh and to provide citizens with real-time tools to find parking spaces faster.

The overall project involved a variety of new technologies, the previous experience of the supplier team on other similar installations meant they were able to address issues quickly when they were encountered. The group of stakeholder and partners worked well as team which has made the trial a success and the project partners are pleased with the results. Which means the plan is to deploy Fastprk in the remaining areas throughout the city as soon as possible.

The Fastprk system includes a Business Intelligence analysis tool which will make results available within the first six months. The trial is still formally running so the final results are not available to share.

The major achievements of the use case for the city and their citizens/visitors is helping drivers find a free spot based on real-time intelligence, to reduce traffic and Co2 emissions as well as to increase citizen satisfaction due to people spending less time looking for a parking space. They do this by using the free App to find parking spaces

The pilot is scheduled to run until the end of 2017. We will then analyze the results and will start the next projects phase which includes installing 10,000 sensors throughout the city.

More information available about Worldsensing parking solutions can be found via this **link**

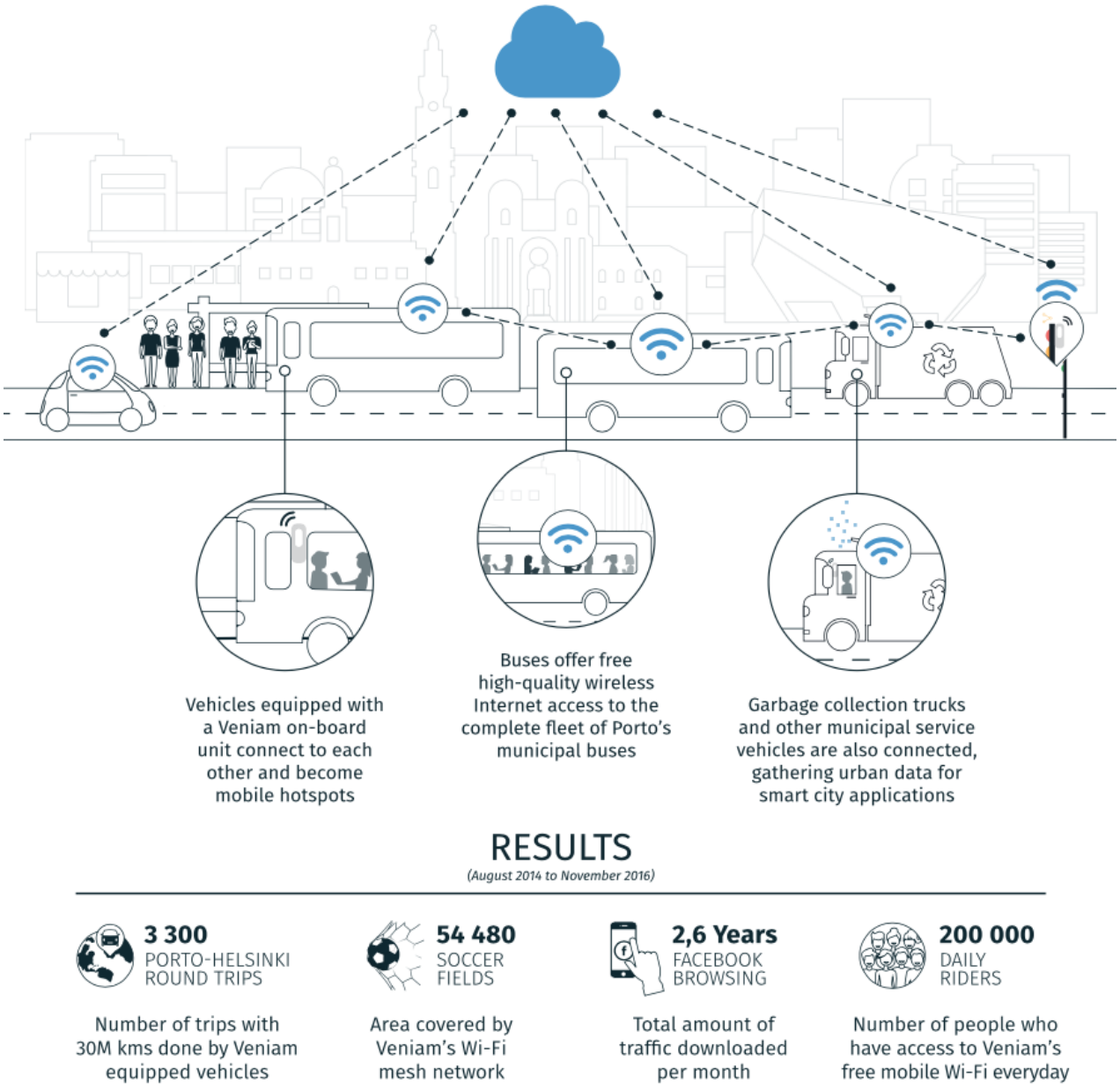

## 6.3 Porto, Portugal turns vehicles into mobile Wi-Fi hotspots

Sociedade de Transportes Colectivos do Porto (STCP) wanted to address the city's critical mobility and transportation challenges. To achieve this objective, the city of Porto needed to implement a platform to build and operate networks of connected vehicles and share urban data.

Veniam's Porto deployment started as a prototype in 2013 and became a commercial deployment in 2014. It continues to be in operation today with over 600 vehicles providing Mobile Wi-Fi and fleet management solutions as well as other smart city applications.

**Porto Connected Transportation Objectives**

- Extend the network to a minimum of 3 fleets of public or municipal transportation
- Design, Develop, Prototype and pilot an open-platform to enable privacy aware access to the city data from third parties and / or internal systems of the public or municipal authorities
- Design, Develop. Prototype and pilot a fully distributed architecture and standardise mechanisms to enable
  - Data collection and transport in the city through standardised interfaces
  - Seamless interoperability among heterogeneous networks, multiple wireless technologies and diverse vehicles from different fleets
  - Large scales storage and data management in the Cloud
- Design, Develop. Prototype and pilot standardized interfaces to provide application developers with the means to simplify application development.




Veniam developed and implemented its hardware, software and cloud components to solve Porto's key citywide mobility and transportation challenges. The V2V (vehicle to vehicle) mesh network solutions deployed by Veniam expands public internet access and collects terabytes of urban data to improve a variety of city operations and urban living conditions making them resource efficient, climate and environmentally friendly.

Today the City of Porto and Veniam have deployed the world's largest network of connected vehicles – a true vehicular mesh network, by expanding the low cost wireless coverage to 600+ connected vehicles, including taxis, waste collection trucks and entire public bus fleet in Porto to enable private, public and municipal transportation operations to be more efficient

Vehicles offer a cost-effective way to expand wireless coverage in cities. They provide the opportunity to gather, share and store the massive amounts of urban data to improve quality of life in cities. With their large batteries, vehicles are ideal hotspots whose dedicated wireless spectrum allows them to connect to each other and the internet.

Using Veniam turnkey solution fleet operators can turn vehicles into mobile Wi-Fi hotspots that are capable of delivering internet access to passengers while collecting terabytes of valuable date for diverse applications in connected transportation, industrial logistics and smart cities.

Porto faced two challenges.

1) The city wanted to improve Internet access for its citizens.
2) Porto struggled with the problem of unconnected municipal services, leading to underperforming city operations, underutilization of key data and inefficient use of critical city resources.

Of the 28 million kilometers per year travelled by 413 service vehicles and 475 public vehicles, 25% of this travel is estimated to be unnecessary, leading to fuel waste, infrastructure over-use, and city pollution.

Specific examples include:

1) Environment: The Largest city vehicle division (yearly budget of $30M U.S.) found garbage collection trucks (yearly budget of $18M U.S.) emptying containers that are less than full, leading excess fuel expenditure and labour expenses
2) Police: Municipal police vehicles were found to be patrolling areas without known incidents
3) Transportation: The economy reduced public transportation, with many buses often carrying Less than 5 people

**The Solution**

Porto used Veniam's solution to deploy a city-scale vehicular network that leverages its large commercial fleets and the existing fibre and Wi-Fi infrastructure. The vehicles include public buses and private taxis that provide passenger transportation, as well as delivery trucks, garbage collection vehicles and street cleaning units.

To connect these vehicles, Veniam developed a multi-network On-Board Unit (OBU) equipped with Wi-Fi I DSRC/cellular interfaces, called NetRider. The NetRider turns vehicles into Wi-Fi hotspots that can deliver Internet access to passengers and mobile workers in and around the vehicles. Additionally, Veniam developed the NetRider Access Point (AP) to connect passing vehicles to the wired infrastructure of various network providers and, ultimately, to the Cloud.

By leveraging the capabilities of DSRC, NetRider OBUs and APs are able to form a wireless mesh network, bringing 10x improvement in reach and 100x improvement in urban-area coverage when compared to conventional Wi-Fi hotspots. A total of 55 Veniam APs has been deployed in Porto's downtown area, bringing the density to 8 APs per square kilometre. During a normal peak working hour, an average of 40 public transportation buses circulate in this area, enabling Veniam to extend the range of each APs via the multi-hop and vehicle-to-vehicle communication capabilities of its NetRider devices. This extended range, in turn, enables the possibility to offload 70% of the data generated in that area, with only 30% of the traffic transmitted via the more expensive cellular connection.

Veniam's approach and methodology enabled Porto to gather terabytes of urban data inexpensively from the city to the cloud. This data is generated by a myriad of sources, from in-vehicle sensors and cameras to the OBD2 (On-Board Diagnostics) interface, as well as

external Wi-Fi/Bluetooth-enabled sensing units spread over the city. The city's 400 plus municipal service vehicles affiliated with the garbage collection, police, and road and building maintenance departments are being used in the full-scale deployment. Once equipped with a NetRider unit, any vehicle can join the network, expanding wireless coverage while offering a solution for the storage and sharing of delay-tolerant data related to city operations. More importantly, Veniam provides Over-The-Air (OTA) updates, as we learn from past performance and improve the software in real-time remotely, allowing Veniam devices and network to continue to evolve even after deployment.

By providing secure access to the data gathered by a large variety of heterogeneous sources of information, Porto's current public/private institutions and fleets, Veniam's Application Programming Interfaces (APl's) will also offer the opportunity for third parties to build and deliver data rich services and cloud applications.

**Porto Smart City Benefits**

Veniam's deployment in Porto has already significantly expanded the spectrum of smart city operations and Wi-Fi coverage for citizens, including:

- Improvement of Porto's city functionality and structure, using information and communication technology as an infrastructure
- By connecting infrastructure to the Internet, it increased life quality and saved money
- The flow of traffic is treated as a holistic system that automatically takes all relevant factors into consideration in real time
- Energy and global carbon emissions savings used by the transport and traffic in the city
- Effectively formed a gigantic dynamic mesh network of constantly communicating vehicles, helping to reduce accident rates
- Aside from the obvious benefits of reducing road traffic incidents, the city's connected vehicles share mapping and traffic data, with the goal of improving the efficient flow of traffic throughout highly congested areas and reduced emissions
- Using sensors, data, such as garage collection, environment insights, driving patterns, vehicle conditions, traffic conditions and accident alerts, are sent to the cloud and analyzed for the benefit of drivers and companies.

**Smart City Lessons Learned**

- Smart cities demand careful planning and, at an early stage. It is essential that national and municipal governments, citizens and all other stakeholders agree on the smart city definition the aim to fulfil. A clear definition or strategy must address two key factors; the cities desired functions and purposes, with its functions referring to appearance and operation of a city, and its purposes to the benefits promised by a smart city model
- Smart Cities monitor and integrate conditions of all of its critical infrastructures, Including roads, bridges, tunnels. rails, subways. airports. sea-ports, communications. water, power, even major buildings can better optimize its resources, plan its preventative maintenance activities and monitor security aspects while maximizing services to its citizens
- A smart city is a city that is performing well in a forward looking way in (economy, people, governance, mobility, environment and living) built on the smart combination of endowments and activities of self-decisive, independent and aware citizens.
- Looking at its functions as well as its purposes, a smart city can perhaps be defined as a city that strategically utilizes many smart factors. such as Information and Communication Technology to increase the city's sustainable growth and strengthen city functions, while guaranteeing & citizens' happiness and wellbeing

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### 6.4 Vivid Sydney: Location Based Services Public Venue:

Vivid Sydney is a unique annual event of light, music and ideas. It is the largest event in the Southern Hemisphere and is sponsored by Australia's NSW Government and corporations to encourage people to come out during the winter season and stimulate the economy in Sydney. Vivid's light festival transforms Sydney into a wonderland of 'light art' sculptures, innovative installations and grand-scale projections. From 23 May to 9 June 2014, the harbor city was awash with color, in what was the biggest and brightest Vivid Sydney festival to date.

Over 1.43 million people attended the 2014 event, breaking the record set in 2013, which included more than 19,000 international visitors. Vivid Sydney provided visitors with over 50 light installations around the city, including Vivid Aquatique Water Theatre at Darling Harbour, Sydney Opera House Sails, Museum of Contemporary Art Australia and Martin Place 'Urban Tree Project'

For the 2014 festival, IBM wanted to use data to create a transformative experience, fusing the physical and digital worlds.

This took the form of a IBM 'Heart of the City' installation, which used data collected from the event and visualized it in a beautiful way. The installation displayed real-time data of the overall foot traffic from the Vivid Light Walk, allowing IBM to display real-time data relevant to the audience in a dynamic way.

"We wanted to visualize and capture the buzz of the event. To do so, we needed to source and find some sort of big data that we could visualize in a physical location at the lightshow, as well as on the web," explained Kurt Solarte, Design and Delivery Lead IBM Interactive Experience.

**Figure 21: Ruckus SPoT™ location technology was used to light up the Vivid installation.**

At the IBM installation in Circular Quay, festival goers were able to view live data highlighting the busiest areas, key destinations and average time spent viewing the installations in the Vivid Light Walk precinct.

This real-time information could not only help visitors navigate their journey on the ground, but also provides valuable insights for festival organizers.

To achieve these goals, IBM required a solution that was proven in supplying wireless capacity covering wide ranges and a complex, high density outdoor environment. It needed to provide

accurate location based analytics of the foot traffic at the event, covering as much of the light walk as possible, which equated to 600-700,000m$^2$.

A key challenge in this deployment was time – it needed to be implemented in a matter of weeks. Speed was of the essence. IBM needed a reliable, robust and accurate location based services Wi-Fi solution. They partnered with Ruckus Wireless and reseller Wired Sky to present the first ever outdoor LBS solution in the Southern Hemisphere.

In the first instance, Wired Sky thought that they would be able to mount the Ruckus Smart Wi-Fi Access Points (APs) on light poles around Circular Quay. However, it soon transpired that this was not an option due to Sydney Council's requirements. "From our perspective, if we had to use a different vendor, we would have walked away from the project and said it couldn't be done," said Matt Hall, Director at Wired Sky. "You have to be very specific with where you place other wireless APs, as you have to triangulate the location of devices and they are less adaptable due to the omnidirectional antennas and fiber cabling requirements. However, with Ruckus and its BeamFlex and Smart Mesh technology, we were confident we could still roll-out the solution."

Ruckus BeamFlex technology was an important piece of the puzzle. Due to the restrictions of mounting APs on the light boxes, they had to install them upside down. Traditional Omni-directional antennas would have failed or performed poorly at this point but because BeamFlex directs transmit energy towards the best path to the receiving

**Figure 22**: Ruckus Zone Flex outdoor access points are installed upside down on the light boxes throughout the Vivid Light Walk, capturing the buzz of the event. device, they worked extremely well. Following confirmation of the final locations of the light boxes, Wired Sky was able to deploy the network within three days.


**Figure 22: Ruckus ZoneFlex outdoor access points.**

Prior to deploying the solution, Wired Sky mapped out the light walk, potential location of APs and light installations. A Ruckus SPoT (Smart Positioning Technology) instance of the map was then created in the cloud. These details were converted to vectored maps, with enhanced details and multi-zones, which could then be amended following the final location of the light boxes.

Ruckus SPoT combines unique advantages, including being completely cloud-based and offering higher accuracy and performance more cost-effectively. This means venues with Ruckus Smart Wi-Fi installed

do not need any additional hardware to be "Location Intelligent" and can take advantage of third party analytic offerings through an open API.

In order to accurately pinpoint in real time a user's location, a onetime calibration of the deployment was required. The Ruckus LBS technology is very simple to use and deploy. Essentially, it's a checkbox on the wireless controller to get the LBS up and running.

There is a small amount of calibration to be done with the APs. This involved downloading a free Ruckus calibration mobile app and marking your specific location in relation to each AP. This took no more than eight hours.

They found the best way to collect the data they required and to capture Vivid's buzz was to use the SPoT cloud services provided by Ruckus. The biggest differentiators was that it is completely cloud-based and the fact they had API access, providing them with easy to use, customizable, real-time location data. All LBS data collected by the APs was sent securely to the Ruckus SPoT Location Engine in the cloud. The IBM Analytic Cloud Engine obtained the Ruckus SPoT data via API calling to provide a customized report. IBM then passed the analyzed information to another system that mapped and projected the density of Wi-Fi devices detected onto the 3D heatmap at the event site, which lit up with different colors to indicate the density of Wi-Fi devices detected.

Access to the Ruckus SPoT solution was essential for the light installation and analysis of the density of Wi-Fi devices. It allowed them to build the solution in half the time it would have taken to custom write it all. The data provided was really accurate and ready to use in an instant. They could get the data from the AP to Ruckus SPoT, to our Cloud Engine and onto the physical display in a matter of milliseconds.

Alongside the light installation, the deep analytics provided by Ruckus SPoT meant that IBM was able to pull some interesting insights for the festival. IBM were able to visualize the footfall traffic, by zone and time, as well as see the total amount of traffic, repeat vs new visitors, average dwell time and dwell time distribution.

The light installation was very popular amongst visitor's due to the beautiful way they visualized the data captured. They found their website, providing a retrospective view of the event, was also very popular. Not only was the LBS technology peaking people's interest internally at IBM, but the public and events organizations, like Vivid, were intrigued by this information.

Over 750,000 devices were detected at the event, with people visiting four installations on average. IBM also found that 7pm was the busiest time during the event, with the average dwell time being almost 12 minutes (from 18th May – 1st June)

## 6.5 Civil Works Control and Monitoring in the City of Barcelona

Project on Civil Works Control and Monitoring, in the City of Barcelona, in order to implement good practices to minimize civil works impacts in terms of noise, dust, vibration and gas to guarantee security and wellbeing to the citizens.

Implementation in the civil works in the Estatut Avenue, between 2011 and 2013 and in the Glories Square since 2014.

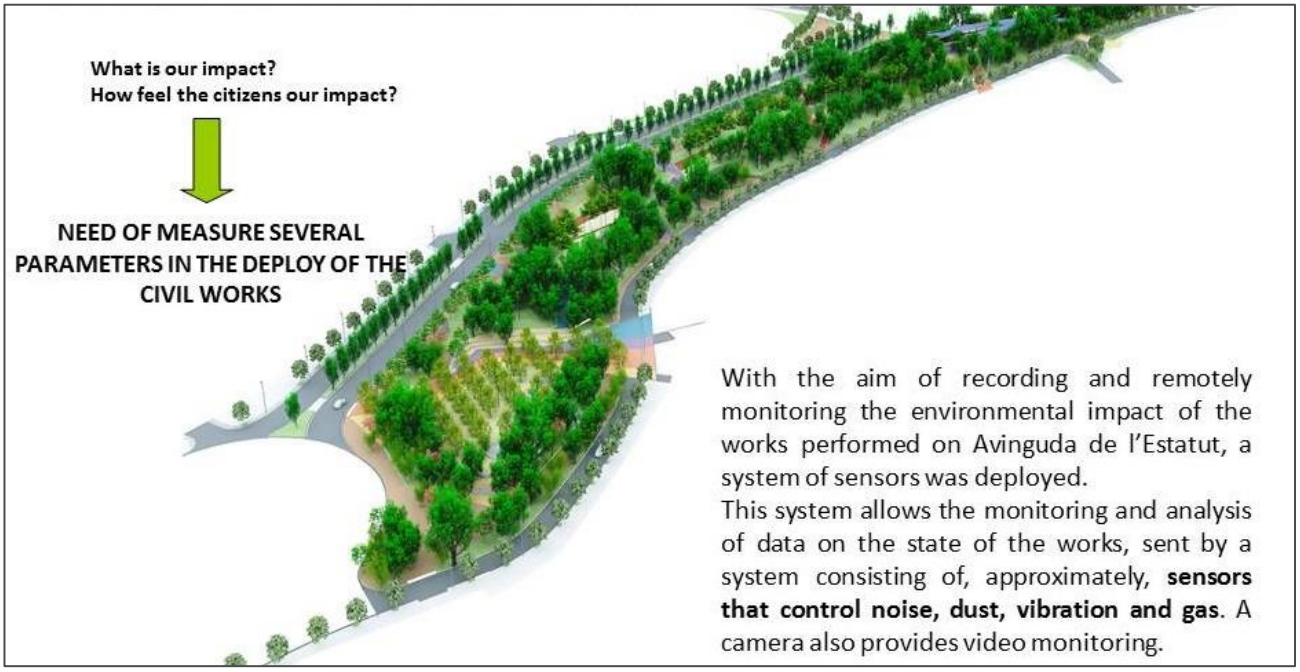



**Figure 23. Implementation in the Civil Works**

### 1) Trash Containers Sensors

Pilot project on trash containers sensors since 2010 for the City of Barcelona.

Test ultrasonic sensors to provide the load information for each trash container. Smell sensors tested as well. Data collected helps to optimize the collections routes and plan for future services.

This project involved citizens and local businesses trash containers.

| Citizens | Stores and Businesses |
|---|---|
| 27.000 RFID tagged trash containers<br>Amount of rubbish per day and container<br>Geocoded information<br>Cleaning trash-containers control | 12.000 RFID tagged trash containers<br>For stores and offices trash containers<br>Data protection standards (ENECSTI) compliant<br>Future service "Pay as you through" |

Table 6-1: Table to show pilot project scope

Figure 24. Photographs of Smart Trash Containers

### 2) People Counting

People counting pilot project in the City of Barcelona from 2013 till 2015.

Test a system for people counting was tested in several areas of the City of Barcelona, including Born, Av. Statute and Glories Square.

There are several systems for people counting. City of Barcelona tested different technologies in terms of count users, preferred displacements, error evaluation and data identity protection:

- IR photodetectors
- Cameras with integrated process
- Radar techniques
- MAC based techniques, including Bluetooth and Wi-Fi
- IMEI based techniques

Figure 25. People Counting

## 6.6 Smart Waste Management Solution for City of Granada

Granada City Council has implemented an urban laboratory in the city of Granada in partnership with Ferrocvial Services and Cisco. Funding for the project was provided by Ferrovial. This is an initiative to digitize Urban Service Delivery by Ferrovial.

It is a pioneering application of data analysis of municipal services. The project focuses on increasing the efficiency of municipal waste collection by using urban data.

The trial started in March 2017 for a 6-month period

The pilot covered 400+ waste bins in the municipality of Granada, Spain. The longer-term opportunity is to scale this to multiple cities over thousands IoT objects.

The urban laboratory was installed in six Granada neighborhoods: Ronda, Zaidín, Genil, Beiro, Chana and Norte. Sensors located in waste bins provided real-time data on their fill status, making it possible to optimize and prioritize waste collection routes.

Applying analytical models and algorithms to the data will enable predictions to be made and truck routes to be redesigned for maximum efficiency.

To carry out this project, a network of communication antennas was installed at strategic points of the city, as well as 420 volumetric fill sensors inside bins, all managed via a cutting-edge city platform which has the capacity to manage municipal services information comprehensively.

The network Infrastructures were provided by Cisco utilizing;

- Cisco LoRaWAN Gateway (IXM)
- Cisco primed ThingPark LoRa Network Server (TPW)

The endpoint sensors were provided by Cisco's IoT partners Sayme and Wellness who provided the LoRa based waste bin sensors

Applications were then needed to connect the devises to the network, aggregate the message protocol and manage the real time and historic data.

**Cisco Kinetics for Cities (CKC):**

- Integrated with the waste sensors via connectivity provided by the LoRa network (ThingPark network server and Cisco LoRa gateways).
- TPW as network based Waste Bins aggregator and exposes message structures over HTTPs protocol to CKC.
- CKC takes the data from the two types waste bin sensor, normalize the data, helps to generate policies and expose data API as per requirements.
- CKC will provide the data for both real time status and historical information

**The objectives and goals of this program were to:**

- Aggregate data from various waste bin sensors, enabling optimization of waste collection process.
- Provide the data for Waste management applications / fleet management applications in a single API
- Display real time status of waste sensors in out-of-the-box CKC Dashboard
- Optimize waste pick up route and resources based on the real-time fill levels and other factors like traffic etc.

Fill data collected by sensors, together with urban information related to weather, traffic and special events, are sent to the Ferrovial Services data analysis platform. Using analytical models and algorithms, each day the platform generates optimal waste collection routes for emptying the selected bins.

The result is a new approach to managing waste collection services based on data and dynamic decision-making adapted to the needs of the city.

The laboratory's goals include enhancing living standards in the city by reducing pollution and noise, since fewer waste collection vehicles are required; improving connectivity and the availability of information about the city; and enhancing operational efficiency.

A collaboration of entitles and providers were involved to deliver this project.

These entities were:

- Service Provider – Ferrovial, an Urban Service Provider who is responsible for waste management
- LoRaWAN Network Provider – Cisco

- Smart City Platform- Cisco Kinetic for Cities
- Sensors/Devices – Sayme and Wellness
- Application Provider – Cisco (CKC Dashboard) and Cisco Partner

The technologies that were used / tested were sensors, Ultrasonic to estimate the fill levels. The sensors send data over LoRa to Cisco IXM LoRaWAN gateways and ThingPark LoRaWAN Network server. Data is retrieved over HTTPS by the CKC platform through ThingPark APIs for data processing.

Granada City Council's partner Ferrovial conducted internal education/orientation to help employees understand how the data impacted how they manage the waste in City.

There are major benefits from this use case;

- Digitization of waste management through waste bin sensors, fleet tracking etc. delivered efficiency in waste pick up, resources utilization and efficiency in number of trips etc.
- Demonstrated the value of a digital platform that is vendor and sensor agnostic to integrate and provide normalized data for transforming a city service

Some of the challenges faced whilst deploying this use case:

- Limited data exposed through APIs from sensor vendors which limits the outcome that can be delivered
- Few sensors failing to connect to the LoRa network due to coverage issues.

This was a fully collaborative project with multiple vendors which worked well with no major hindrances encountered.

Future areas of improvement and development could be applying predictive analytics modeling on top of CKC waste management data and providing a mobile application to truck drivers for end to end lifecycle management.

A sensor and device eco system that has mature API based approach that exposes all important and relevant data to application eco system

Results that are measured and evaluated:

- Persistent connectivity from waste sensors to CKC over LoRaWAN network
- No traffic/data loss seen from the Waste Bin Sensors on CKC platform
- Successful delivery of all customer requested KPIs and metrics which included trip and resource optimization for waste pick up
- Availability of historical reports and data APIs for 3rd party applications
- Visualization of real time waste sensor data on CKC dashboard

The historical waste collection data from CKC to quantify the benefits of this PoC for the city and their citizens/visitors are still in the process of being analyzed.

Citizens are engaged in this project indirectly, as they receive the benefits of better waste management in the form of less rounds of waste trucks in the city during peak hours, reduced congestion, reduced instances of overfilled bins so on and so forth.

The digital platform can be enhanced to include Citizen feedback and grievance redressal related to waste management in their Cities

At the beginning of the project we agreed on a set of goals and metrics that CKC will deliver. All have been delivered timely.

Recommendations we would have for other cities who decide to develop a similar use case.

- Access to operator's data like number of trucks, trucks capacity, landfill locations, start time and locations, key routes will help better design the dashboard application.
- City Services Digitization is key for better urban services. Selection of vendors and partners, technology partners and O&M partners is key.
- Radio planning is required to ensure full area coverage

This pilot opens smart cities opportunities to replicate the same model in other regions.

If we were to do this project again we would ensure more accurate Radio planning is performed to ensure proper area coverage. overall no other significant changes to the processes.

View the Case Study Video

View the Press Release from Ferrovial

## 6.7 W-Fi Connectivity and Broadband Proliferation, Singapore

Infocomm Media Development Authority of Singapore (IMDA) continues to make strategic investments to deploy seamless, trusted and intelligent Next Generation National Infocomm Infrastructure (Next Gen NII), which complements the country's role as a major global telecommunications and convergence hub where regional submarine cable systems and international cable systems interconnect.

Next Gen NII opens the door for players from the entire telecommunications value chain (hardware providers, systems solution integrators, vendors, enablers and content players) to participate in Singapore's enlarged broadband market, so as to boost connectivity and broadband proliferation.

**Laying the foundations**

Next Gen NII includes a pervasive Next Generation Nationwide Broadband Network (Next Gen NBN), where households and businesses leveraged on the ultra-high speed access speeds and innovative services. The Next Gen NBN adopts the Open Access model that transformed a vertically integrated telecoms market to one with three horizontal separated layers. The Open Access environment enabled a growth of thirty (30) retail service providers, thirteen (13) active infra companies, and one (1) passive infra company to help deliver a wide range of high speed applications and services to consumers.


**Wireless@SG Programme**

Wireless@SG is another initiative under the Next Gen NII, providing free Wi-Fi services in public spaces, in collaboration with venue owners and service providers. Wireless@SG is a federated model where IMDA appoints a number of service providers to operate public Wi-Fi hotspots, all subscribing to common login and security standards with local roaming. This allows users to access all Wireless@SG hotspots across Singapore in a seamless and secured manner using a single account. Through this, service providers are able to market and deliver a commercial off-the-shelf Wireless@SG services for enterprises.

Wireless@SG is approaching its 11th year since inception. Today, there are about 14,000 hotspots deployed in the city of 5.5 million people. The goal is to reach 20,000 hotspots by 2018, bringing us to 1 hotspot per 277 people. This is no mean feat as this number only takes into consideration the hotspots that are part of the Wireless@SG federated network; without accounting for other "privately branded" public Wi-Fi hotspots provided by malls, cafes and hotels.

Although mobile penetration in Singapore is very high, about 2 million unique users actively access Wireless@SG on a monthly basis; equivalent to a third of Singapore's total population with usage at approximately 11 hours per user per month. This shows that these users, even though they have cellular data access, find Wireless@SG useful for their needs.

Wireless@SG adopts an industry partnership approach to enable sustainability and innovation. All deployed Wireless@SG hotspots are sustained though commercial arrangements between the demand (i.e. enterprises and government agencies) and supply agents (i.e. Wireless@SG service providers). Typically, demand agents leverage on the Wi-Fi infrastructure for their own operations and productivity. Service providers monetise by providing services over the Wi-Fi infrastructure. Free Wi-Fi for users is thus "cross-subsidised" through this arrangement between demand and supply agents.

Additionally, IMDA has been actively participating in Wireless Broadband Alliance Connected City Advisory Board's City Roaming Projects in 2016 and 2017. In both years, through the support from the Wireless@SG operators, the Wireless@SG programme was able to roam with selected cities allowing

users to seamlessly connect to the participating Wi-Fi networks. Through these efforts, IMDA looks forward to continuing working through the Connected City Advisory Board in establishing a framework where such initiative could be scaled to include more cities, achieving the vision in accelerating global wireless connectivity, providing all users the same standardised and consistent user experience.

**HetNet**

Heterogeneous Network (HetNet) is a technology IMDA are exploring into to improve Singapore's connectivity framework. It will be an integral communications tool for a pervasive and robust connectivity which could allow seamless exchanges between networks i.e. cellular and Wi-Fi. Additionally, it also utilises small cells that has synergy with existing macro cells to strengthen network capacity and enhance the mobile user experience. As a result, this will also encourage development of innovative ideas in services such as remote health monitoring, video calling on the move, and voice over Wi-Fi.

All these initiatives create the perfect ecosystem to generate innovation bringing about long-term competition and vibrancy in the infocomm industry for Singapore.

## 6.8 Harlem Free Public Wi-Fi Network

Following the deployment of the Harlem Free Public Wi-Fi Network, which provides Wi-Fi access to approximately 80,000 residents across 95 city blocks, New York City Department of Information Technology and Telecommunications (DoITT) solicited proposals from various industry experts to conduct a comprehensive network assessment.
The Project scope:

- A physical site survey to measure the true coverage area and equipment performance.
- Assessment of existing bandwidth and opportunities for expansion.
- Recommendations for improving service and identification of new locations on which to mount additional access points.
- Review and analysis of network hardware and software, including the network management tool.

Recommendations to upgrade the network to increase user speeds to at least 25 Mbps.

DoITT set out to conduct a comprehensive network assessment to ensure that a significant public/private investment in Wi-Fi is fully and efficiently implemented to deliver the best possible service to the public and to make recommendations as to how it can be improved. Recommendations made pursuant to the assessment will help inform decisions that DoITT will make with regards to potentially upgrading the network to improve speeds and/or expand the coverage area. DoITT also analyzed the results of the "pilot" assessment to help determine if it should conduct similar network assessments on existing incumbent Wi-Fi networks and their providers.

The entities involved in these projects were Silicon Harlem & Kalpesh Wireless.

Silicon Harlem is a technology and advocacy group focused on advancing broadband services in Harlem. With their technical experience and close relationship to the community, Silicon Harlem is uniquely qualified to perform an assessment evaluating the efficacy of the network and its community impact.

Kalpesh Wireless is a market leader in municipal and private Wi-Fi networks and assisted Silicon Harlem in conducting the assessment.

To test the propagation of the Wi-Fi signal and coverage area, Silicon Harlem measured the Signal to Noise Ratio (SNR) and Received Signal Strength Indicator (RSSI).

The network assessment provides insight into the performance of the Wi-Fi network (and vendor) to ensure that the public receives a quality Wi-Fi experience. Results of the assessment can identify network deficiencies and credibility issues which may necessitate a plan to mitigate the issues. The findings and conclusions from the comprehensive network assessment will help the city to make informed decisions with respect to the allocation of resources for future wireless deployments.

The solicitation of vendors to perform the assessment and the project itself was performed professionally and expeditiously and yielded good results.

DoITT distributed a clearly defined solicitation stating the project's goals and scope of work to a host of highly qualified vendors. The responses received were very impressive and demonstrated a wealth of skilled vendors capable of performing the services. The selection of the "right" vendor for the particular project is essential to deliver the desired result.

The Harlem Free Public Wi-Fi network assessment identified shortcomings in the network such as in many locations the throughput fell below the minimum 2 Mbps threshold. Recommendations to achieve user speeds of at least 2 Mbps included adding additional strategically-placed gateways and access points as well as upgrading from a 35/5 backhaul connection to a 300/20 connection. Further recommendations to achieve significantly higher user speeds of at least 25 Mbps include deploying a hybrid fiber-fed point-to-point network and upgrading access points using the 802.11n standard to 802.11ac Wave 2 technology. The backbone of the hybrid network would leverage 1+ Gbps fiber lines installed to support the City's LinkNYC kiosks.

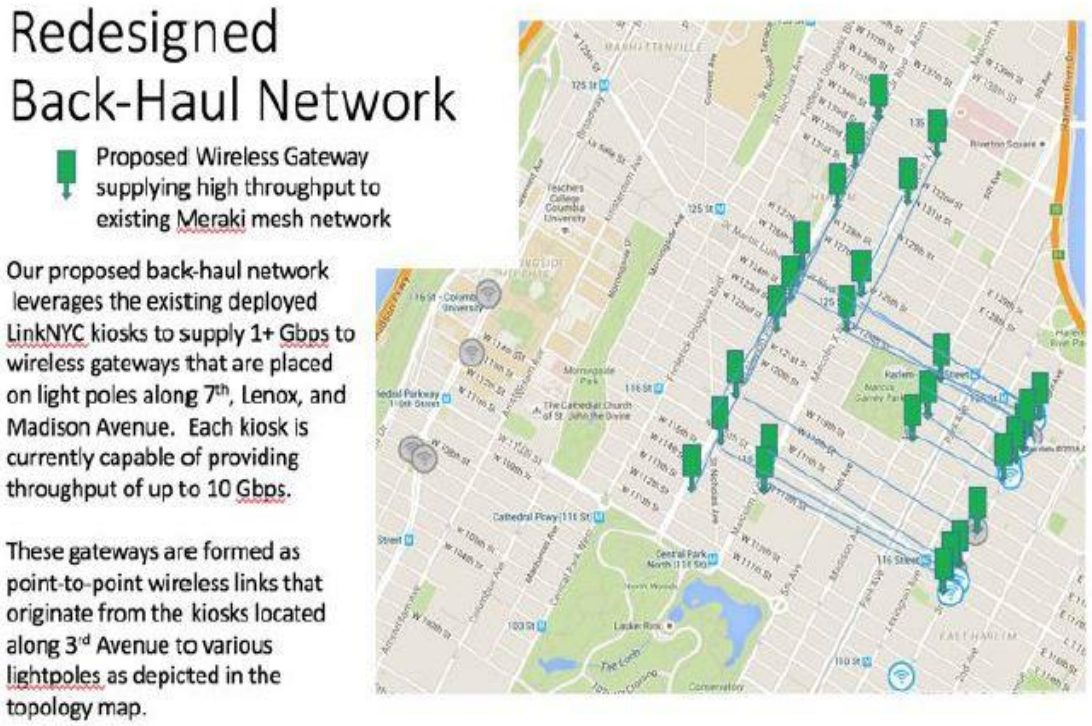



**Figure 26. Redesigned Back-Haul Network**

The final assessment report detailed a number of shortcomings in the network's design and operation and offered specific recommendations to remediate those issues.

Taking into serious consideration the suggested recommendations, DoITT has initiated the process to identify a plan to immediately resolve the short-term issues affecting the network's reliability and performance while also formulating a plan to significantly expand and future-proof the network.

The report's findings also provided insight into whether or not the city will conduct future business with the network provider as well as the inclusion of added City oversight measures in future network deployments.

DoITT is committed to expanding access to broadband services throughout the city, particularly in underserved communities. To ensure that those services adequately meet the needs of its citizens, and after reviewing the results of the Harlem Wi-Fi network assessment, DoITT intends to increase standards for future network deployments requiring providers to install robust, future-proof networks and institute more stringent monitoring and maintenance protocols.

Municipalities may be deterred by the cost associated with conducting the network assessment, however the report's findings provide tremendous vision into the network's true performance that would otherwise not have been visible to the city.

DoITT anticipates conducting similar network assessments for other existing and future Wi-Fi projects that are funded by the city and/or utilize city-owned property.

With the increase in city-sponsored public Wi-Fi networks, DoITT is motivated to continue to find new ways to make certain that the city's residents and visitors have access to quality wireless networks. Future network assessments will likely include an even broader range of potential vendors and an enhanced scope of work.

Potential projects include network assessments of the city's LinkNYC kiosks and Transit Wireless subway Wi-Fi network.

### 6.9 Next Generation Hotspot Deployment for Public Access: City of San Jose Final deployment

The City of San Jose had big expectations for the new Wi-Fi infrastructure that would initially cover 1.5 square miles of outdoor space downtown.

They wanted to extend signal coverage, increase concurrent client capacity, improve reliability, reduce the cost and complexity of trenching fiber, simplify management and centralize administration at the lowest CAPEX and OPEX possible.

The city also needed to extend Wi-Fi services within high density indoor environments including San Jose's Mineta International airport and the McEnery Convention Center.

The entire indoor, outdoor Wi-Fi infrastructure needed to be highly scalable and unified through a common management framework.

Deploying the new Wi-Fi network was completed over a short timescale for the City.

After replacing the existing legacy infrastructure, it was concluded that expanding the capacity would be too onerous. More wired connections would be required to expand the network and cover the larger footprint of the city.

Rich with fiber assets and bandwidth coming from MAE West, an Internet peering point located downtown at 55 Market Street, backhaul capacity wasn't a problem. However, running this fiber to every Wi-Fi node where service was required was a problem.

So they introduced the Ruckus technology which allowed APs to be to daisy chained using smart wireless meshing which created a unique and clean solution to the problem.

Using ZoneFlex three-stream, dual-band 802.11n outdoor units has allowed the City to easily expand network capacity and provide expanded coverage throughout the city as needed without expensive fiber trenching to AP locations.

Having rolled out one of the first municipal outdoor Wi-Fi deployments in the nation using legacy Wi-Fi technology, San Jose was challenged to keep up with a growing number of users armed with multiple and more powerful Wi-Fi enabled devices.

Moreover, user expectations for access to stream video and multimedia rich applications predicated a smarter and more industrial strength wireless infrastructure was needed beyond the free and fast public access.

The city viewed a reliable Wi-Fi infrastructure as essential to future economic development, attracting new businesses downtown and efficiently delivering and supporting a whole new generation of city services — from Wi-Fi-enabled parking meters to streaming video.

Some of the benefits include:

- Public Wi-Fi access speeds ranging from 4 to 6 Mbps up and down per client
- Reduced CAPEX from higher capacity and performing APs requiring fewer APs than competition
- Reduced OPEX from Smart Meshing
- Easy and cost-effective configuration and installation

After the successful launch of its outdoor Wi-Fi network, San Jose began deploying indoor Wi-Fi. Hundreds of dual-band, three-stream, ZoneFlex 7982s 802.11n access points were installed in the McEnery Convention Center and a similar indoor network, replacing legacy W-Fi gear deployed at the Mineta International Airport to ensure a consistent and high-speed user experience.

Looking forward, the City is planning to leverage new Hotspot 2.0 technology to give users seamless roaming between other Hotspot 2.0 networks as well as automatic and secure provisioning of end devices without tedious configuration to and the right Wi-Fi network.

A terabyte of throughput is now commonly pushed through the Ruckus network daily as data traffic continues to increase. And clients enjoy up to four times the uplink and downlink speeds compared to the legacy Wi-Fi network.

## 6.10 Historic City Mesh Network for Public Access: Final deployment

As part of its plans to deliver a modern connected city, the City of York Council deployed a high capacity, high-speed, city-wide Smart Wi-Fi network. Smart Wi-Fi solutions provider Ruckus Wireless was commissioned along with managed service provider, Pinacl to install aesthetically pleasing equipment that complied with the historic appearance and wouldn't spoil the city's image.

Many visitors to the historic City of York come to sample the delights from Betty's Tea Shop near Coney Street, or visit the Museum Gardens for the outdoor concerts, weddings and York Museum itself.

Alternatively, they travel to the edge of the city to see Rowntree Park, a recreational space donated by the world-renowned confectioners to the memory of the Cocoa workers who fell during the Great War.

Now, they can do so and enjoy all the benefits of free Wi-Fi access too.

In late 2011, the City Council embarked on an ambitious program to modernize its IT facilities so its inhabitants, business users, and the millions of tourists to the city each year could gain access free Wi-Fi services.

The Reinvigorate York and Digital York initiatives set out to create a modern, connected city for many years to come. York city council had already embarked on an ambitious digital plan, installing the largest metro fiber network in the UK, providing gigabit connections to nearly 200 locations.

The next stage of the plan was to connect three vital hubs in the city without disrupting the architecture of one of the UK's most historically important cities.

As the council's managed service provider, Pinacl selected Ruckus Zoneflex 7363 dual-band (2.4/5Ghz) indoor 802.11 mid-range access points featuring Ruckus Beamflex adaptive antenna technology to provide reliable, consistent, high-performance coverage.

In addition, the Ruckus Zone Detector management platform was deployed to control and monitor service delivery and performance.

Each of the three sites presented their own particular challenges to the Pinacl team.

Finding suitable buildings to locate Wi-Fi units in Coney Street and St Helen's Square proved difficult, as they were all owned by private landlords.

The Pinacl team found the solution in the council owned property they had to hand – the lampposts and street lighting infrastructure. It meant the six-wireless hotspots could connect to a local power source, making them almost completely unobtrusive from street view. In addition, the mesh configuration eliminated the need for a cabling network, whilst communicating with the existing wireless service at the local Explore and Leisure centers.

Rowntree Park presented another problem altogether, in that it lacked any suitable buildings to locate Wi-Fi points. The only obvious solution appeared to be place the Wi-Fi access points in trees, could prove problematic when they were in full-leaf, which would have created the same issues buildings create i.e. to block out signaling traffic.

So the most suitable approach was in fact to install two flagpoles to fix the access points. As the park already had an existing flagpole, the solution was in keeping with the existing environment.

The final installation, at Museum Gardens, was a site of special significance. Pinacl worked with the council's conservation officer and English Heritage to ensure its approach was as unobtrusive as possible. As the Ruckus 7762 access point has an internal antenna, its external environmental footprint is as small as possible, significantly helping the aesthetic appeal.

The ease of installation of Ruckus' equipment directly addressed the Council's requirement for rapid fitting – all three sites were installed, up and running in the space of a few days.

After the first three months of operation since its full launch in January 2013, more than a million users have accessed the free Wi-Fi services without a single customer complaint about the service.

With a successful trial under its belt, the City of York is looking to expand its Wi-Fi hotspot across the area within the city walls. The city council were impressed with the Ruckus solutions and are now looking

to extend its relationship beyond its existing installations, to ensure that the entire city environs are covered in a Wi-Fi hotspot zone.

### 6.11 Limerick City & County Council. Municipal Data Network for CCTV

Limerick Digital Strategy - Limerick Municipal Data Network, launched in May 2012 but is still expanding.

The scope of this project was to assess the viability of using city assets (ducting, street cabinets, access chambers) in developing and expanding a city owned high-speed, high-capacity fiber network to connect any council buildings, operational depots and any other city-owned data sources.

- To expand the existing CCTV fiber network and connect City Hall and the Emergency Services Campus (Munster Regional Control Centre and Limerick City Fire Station)
- To upgrade older analogue CCTV to IP CCTV to create additional capacity in the existing fiber networks. To transfer traffic controllers to this network and reduce communication costs
- To enable the roll-out of additional CCTV (e.g. the Limerick Canal walkway as part of Smarter Travel Limerick, Regeneration CCTV)
- To develop a dedicate infrastructure for Wi-Fi and IoT pilots as part of the Howleys Quay re-development
- To provide a live connection to An Garda Síochána (Police) to 2 major CCTV centers


**Figure 27: Creating High-Speed, High-Capacity Municipal Data Network**

Limerick City & County Council wanted to use existing city infrastructure assets to create a high-speed, high-capacity municipal data network, a backbone for connecting any council buildings, city data sources (CCTV, Traffic controllers, Wi-Fi, etc.) and support the future roll-out of IoT.

The following entities are involved on this initiative: Limerick Regeneration, An Garda Síochána, Munster Regional Communications Centre, and Bandwidth Telecommunications

Limerick Regeneration is responsible for the Framework Implementation Plan one of the largest capital programs in the State. The Plan includes a €253m investment on physical, €30m on social and €10m on economic programs.

Munster Regional Communications Centre is responsible for the efficient and effective mobilisation of fire appliances and other agencies with the Munster region.

Bandwidth Telecommunications are system integrators with over 20 years' experience in design, installation and maintaining a wide range of technology solutions.

The following benefits are the result of the project:

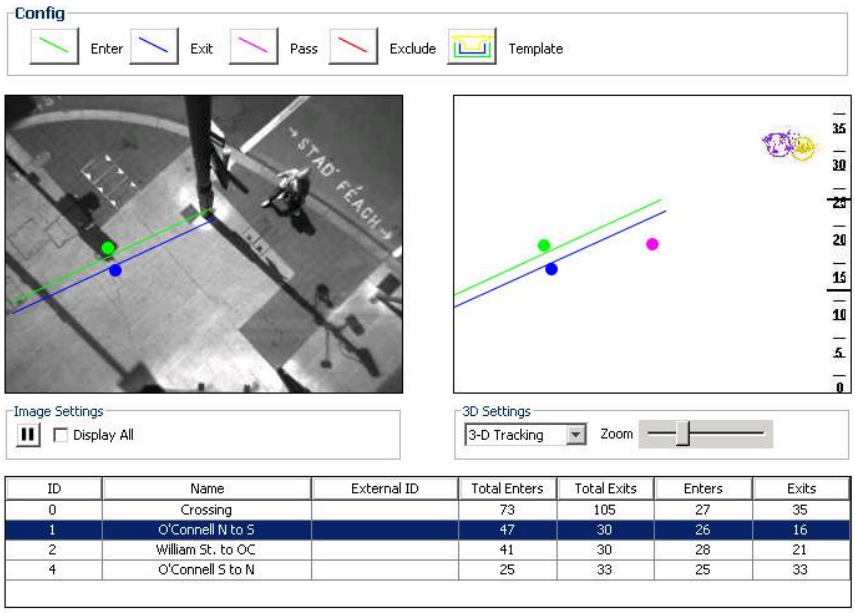
- Improved public safety by connecting a community based monitoring centre and the police force to previously isolated CCTV
- Increased speed and reliability of city communications infrastructure
- Creating opportunities for IoT deployments: footfall sensors, CCTV and traffic monitoring sensors have already been added to this network;
- Creating opportunities for cost sharing of communications costs therefore connecting more devices and locations
- Improved DR and backup capacity to any location in the network
- Demonstrates how to maximize the untapped potential of the city's infrastructure assets in order to create new data communications capabilities for Limerick

No major challenges were encountered. However, identifying and maintaining a register of city assets (ducting available in footpaths and roads) can be problematic. In the discovery phase, interviews with engineers, technicians and contractors helped us identify information about city assets from previous project plans and aggregate this information in a GIS system.

The Digital Strategy Department worked across the Council in close co-operation with ICT, Traffic Management, Community Support Services departments to put forward a proposal to other agencies for co-creating this network and sharing costs. The proposal was very well received and the benefits of the project increased as more agencies joined the project.

**Future areas of improvement:**

- Further expanding the use of the network
- Development of a self-monitoring and alert system on the network
- Development of a network loop across the city in order to increase resiliency
- Mature the governance and operational processes




| ID | Name | External ID | Total Enters | Total Exits | Enters | Exits |
|---|---|---|---|---|---|---|
| 0 | Crossing | | 73 | 105 | 27 | 35 |
| 1 | O'Connell N to S | | 47 | 30 | 26 | 16 |
| 2 | William St. to OC | | 41 | 30 | 28 | 21 |
| 4 | O'Connell S to N | | 25 | 33 | 25 | 33 |

**Figure 28: Identifying and Maintaining City Assets**

To evaluate the success of this project LCCC uses

- The number and type of devices connected in this network as an indicator of the service uptake; and also the number of devices and locations that are still unconnected;
- The communications costs vs. using point solutions (3G, dedicated lines, radio, etc.)
- The impact on the local community in relation to safety and reduced antisocial behavior

LCCC are committed to implement the Limerick 2030 Economic and Spatial plan and take full advantage of Digital and ICT technologies in the development of Smart Limerick in order to:

- Create smart communities and safer communities
- Create new social and economic opportunities for all, through the use of technology
- Create a better citizen, visitor and customer experience

Municipalities should keep an updated infrastructure assets register (besides the financial asset management register) and if one does not exist, start its development by capturing the knowledge of their staff and contractors.

Develop internal processes that will facilitate keeping the infrastructure assets register up to date and engage with other agencies: the business case for shared development increases in value created as more agencies take part.

LCCC anticipates that this network will be further expanded as the city streets are upgraded, for example the €8 million O'Connell Street (main thoroughfare) upgrade will see an expansion of the network and the use of different types of IoT devices.

As the municipal, data network expands and new data is being captured while we are developing "Insight Limerick", a data aggregation, visualization and analytics service that will allow us to make better decisions based on insights from this new data.

We are currently working on Limerick Enterprise Architecture for Smart Cities with LERO across universities research groups based in the University of Limerick

### 6.12 Malaysia: Smart Traffic Management System

Development of a Smart Traffic Management Systems for the city of Cyberjaya in Malaysia.

This project includes the following blocks: Traffic lights, Traffic sensors, CCTV with traffic counting analytics and Adaptive controller systems.

With the objective to implement a system that:

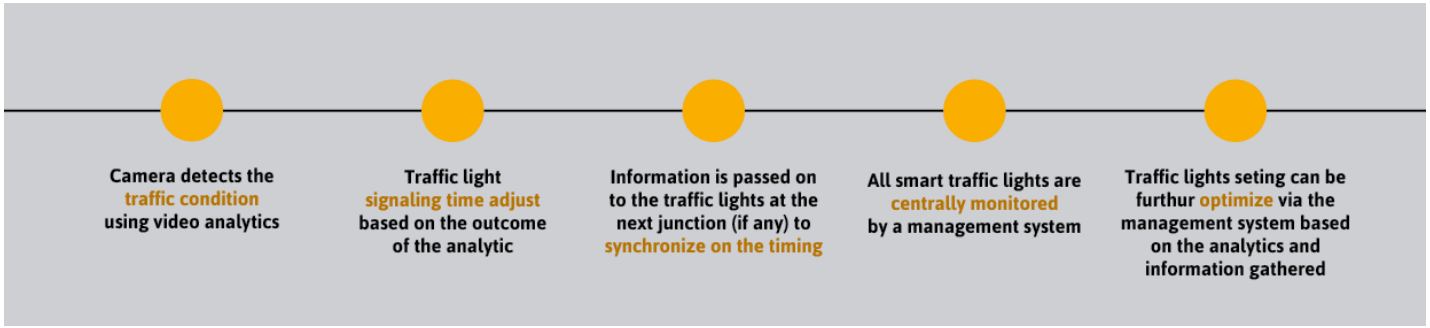
- Auto-adapts and auto-optimizes traffic lights to reduce traffic congestion,
- Reduce waiting time at traffic intersection
- Savings on petrol and CO2 emission affecting everyone
- Remote management

Through understanding the traffic condition and behavior via traffic sensors and CCTV analytics, the smart traffic signal control system can automatically distribute green time to all traffic lanes and adaptive to fluctuating traffic volume to enhance rapid traffic movements. This would result in reduced travel time, waiting time and directly addresses traffic congestions while accommodating to multiple variable/unpredictable traffic demands.

The objective was to address the following issues:

- Long queue due to inefficient traffic light signaling
- Cars stop at every traffic junction because the traffic lights are not in sync
- Traffic light signals are set to a fix timing rather than automatically adjust according to traffic condition

The project is summarized in the following chart that describe the main blocks of the smart traffic management system:



The implementation of this system brought the following benefits:

- Less time spent on waiting at the junction
- Smooth journey from one junction to the other
- Reduce traffic congestion in the city
- Able to remotely monitor and control traffic light signal to accommodate multiple variable/unpredictable
  traffic demands

The following figure identifies the flows of activity of the Smart Traffic Management Systems of Cyberjaya.

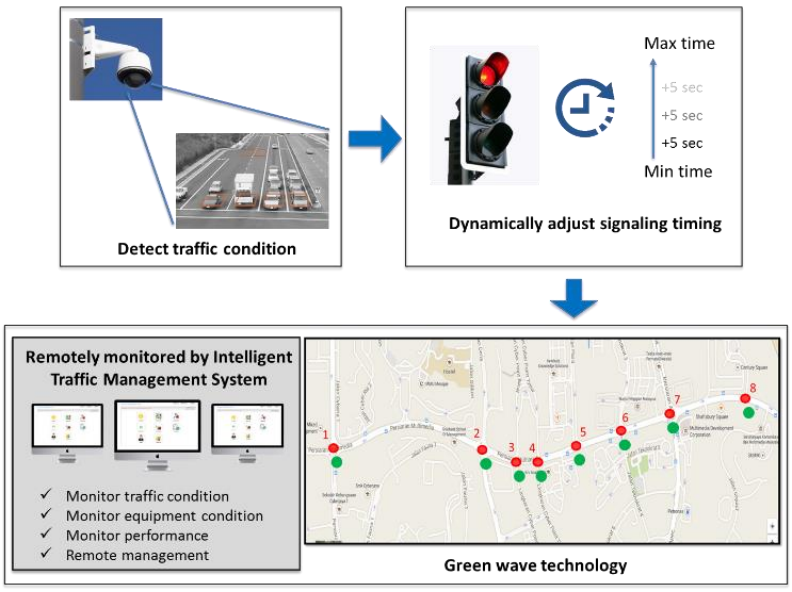



**Figure 29. Flow of activity of Smart Traffic Management Systems**

Video analytics data being sent to local traffic controllers and command centers. Local traffic controllers will process analytics and adapt to traffic conditions.

Traffic management software would be able to remotely monitor and manage traffic controllers (override if required).

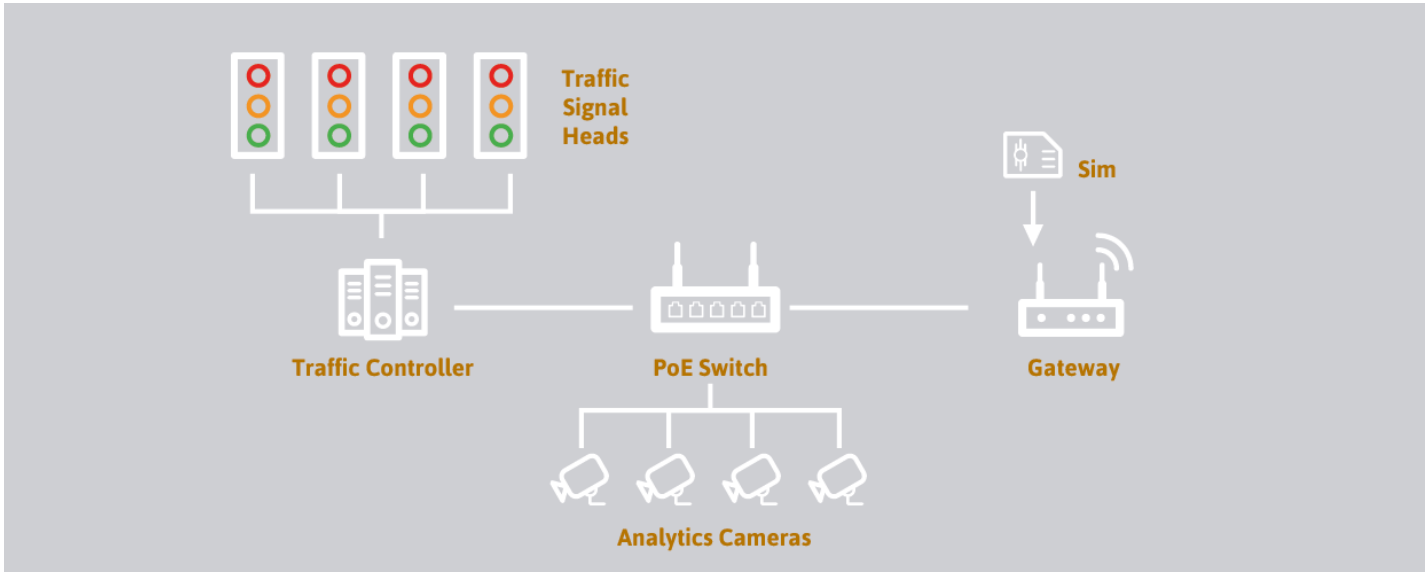



Figure 30. Local infrastructure installed

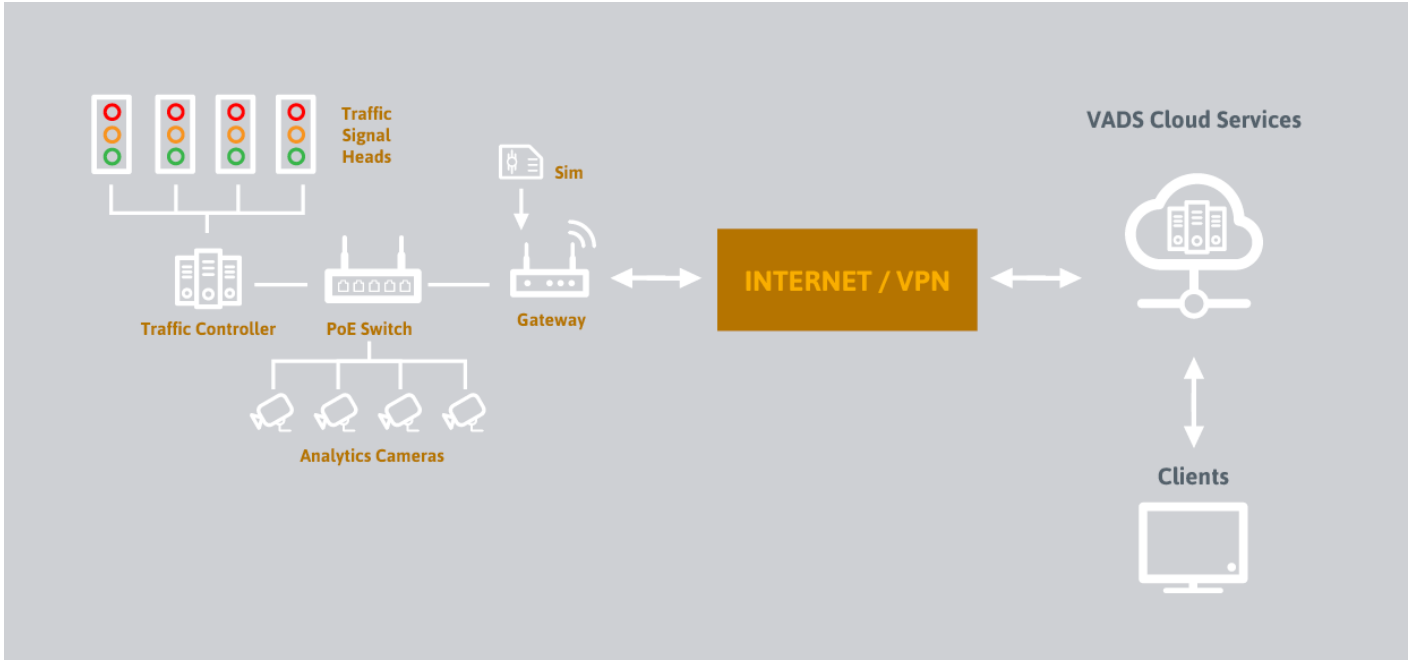



Figure 31. Remote Monitoring Architecture

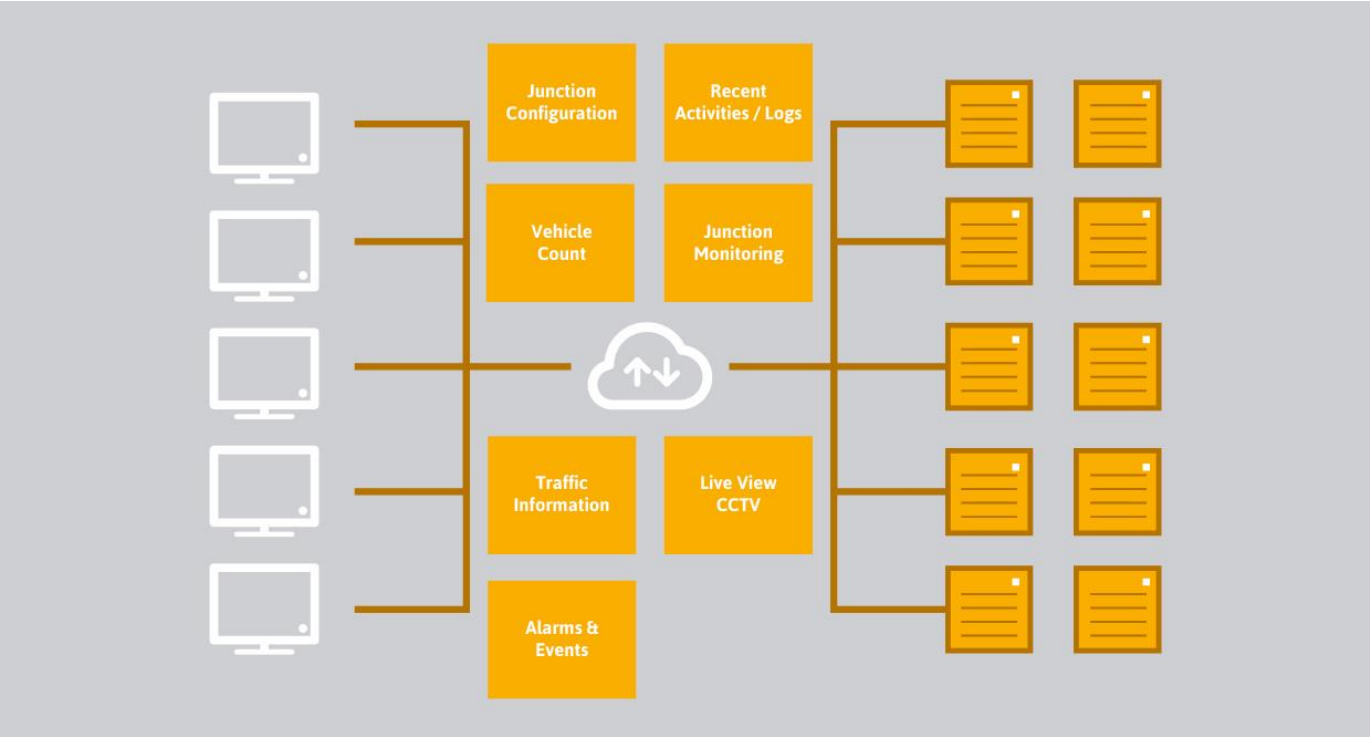



Figure 32. Remote Management Platform building blocks

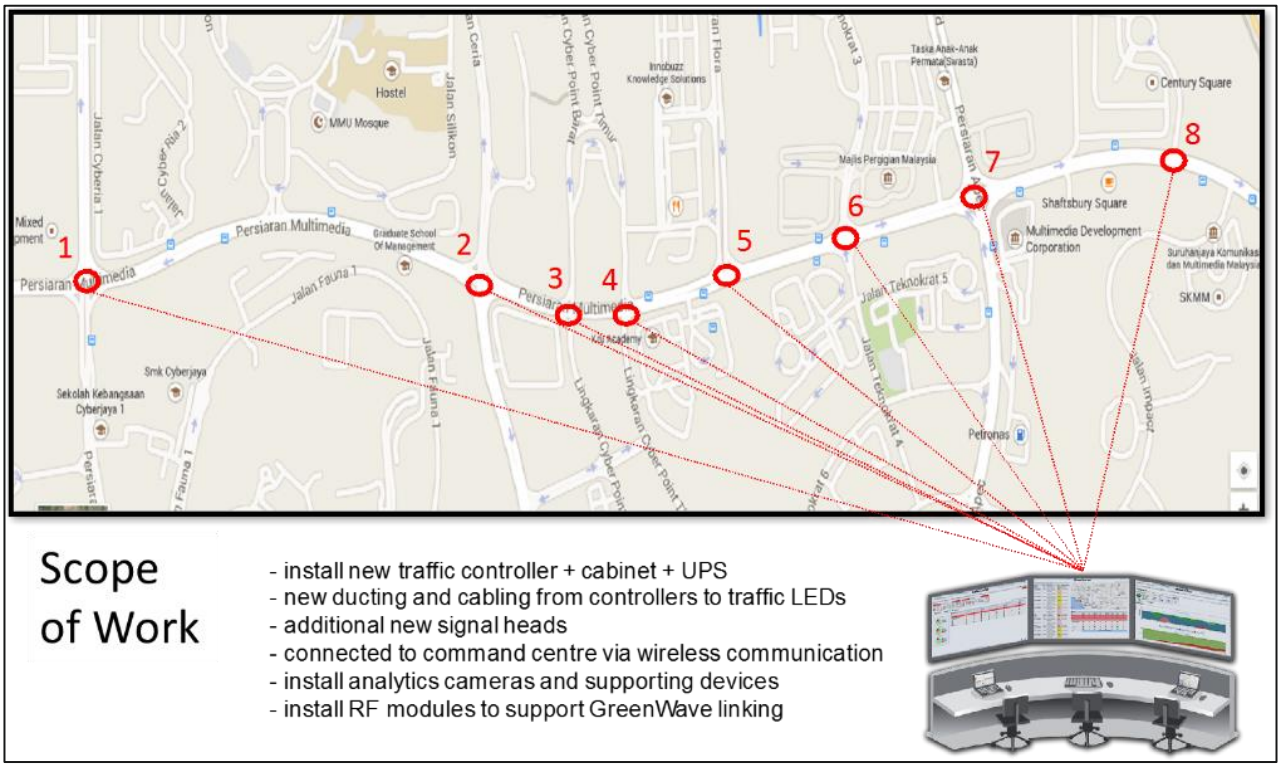



Figure 33. Scope of Work

# 7 Connected City architectures & framework

The first step is to identify several facts in applications of smart city concepts:

- Increase in new telecommunications services demand,
- Increase of migration between fixed and mobile applications,
- Increase of mobile applications costs
- Need of guidelines on QoS, data protection, resilience and security for new services.
- Most of the above facts generated silos solution for each services set.

The value chain and comprehensive platform supporting it, can be structured in 5 steps as shown in Figure 34.

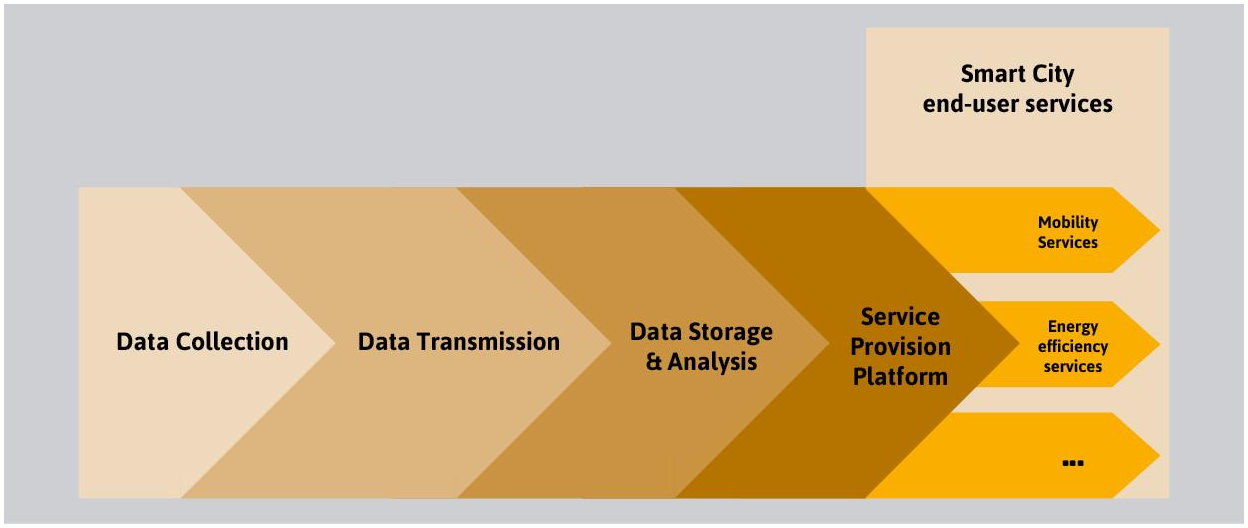



Figure 34. Value Chain and Supporting Comprehensive Platform

Where the data collection stage includes sensors, devices, social networks, physical infrastructure and other existing sources of information, actuators are considered as providers of its state data.

All data collectors send information using light protocols to gateways that route data through fixed and mobile networks to a data warehouse. This sector could work automatically (i.e. M2M)

Services interact with data warehouse in order to provide information to services and from services to data warehouse.

The main objectives of a comprehensive system for smart city management are:

- Compiling information on the city complying with the pertinent privacy legislation.
- Distributing information, processed or unprocessed of the different services.
- Analyzing information according to the defined criteria.
- Making decisions by returning the refined information to the systems carrying out the different tasks.
- Making data and capacities available in open format to society.

It is essential for smart city services to be supported by platforms that ensure they are correctly functioning, in terms of efficiency, performance, security and scalability as well

## 7.1 Modelling City Services

Cities have deployed services in the past as silos due to an unintegrated city vision, where all services made its systems, networks and devices think only about its specific service requirements.

The future of Smart Cities goes to reuse resources in different services and think deployment in terms of a common conceptual management of resources (networks, databases, systems evolving from legacy to a new public management space model.

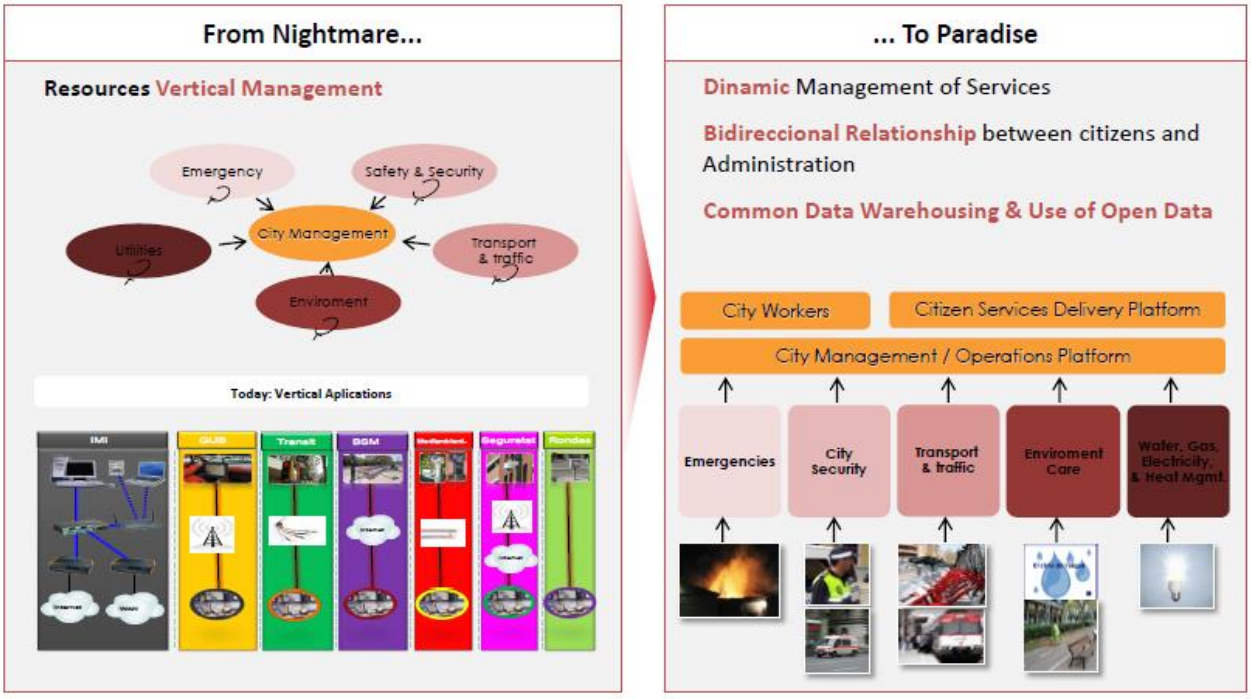



**Figure 35. Smart Cities, From Nightmare to Paradise**

Moreover, it will be a key issue to have a common definition of services where we can distinguish between services perceived by users (Final Services) and its parts as service (Basic Services).

All Basic Services could be modeled to a “Standard City Reference Unit” that permits city government to see most of the city’s services in terms of repeatability.

For example, in Barcelona they use “Macroblock/Superblock” (Supermanzana in Spanish). Macroblocks are defined theoretically as an "area of urban organization, from which a series of structured transformation strategies towards a new urban model, where mobility and reorganization of public space represent the first step”. They represent a population between 5,000 and 15,000 in an area without car traffic surrounded by high traffic streets. That permits a model/service in the Superblock area (i.e.: 2 sonometers/macroblock), and as a consequence, obtains a model for all the cities model as addition of macro blocks.

A clear definition of roles for ICT components in final services follows:

- City Council Technical Service Users (Police, Firefighter, Inspectors,) define QoS:
  - Physical parameters will be measured,
  - Kind of sensors/actuators that will be used for a specific service,
  - Position for specific purpose
  - How to install these devices in the streets
  - The effectiveness of the user interface
- City Council ICT Department define ICT Related Basic Services:
  - The adaptation layer in IoT Network to adapt data offered and actions permitted to a Dynamic User Interface desired by Users.
  - Intelligence, privacy, addressing and security issues (DHCP, wpa2, AES, VPN IPSec,) and its location.

From this point, ICT Department established in each RFP process key selections in order to normalize installation, access, transport network and data warehouse, example:

- Transport Network based in TCP/IP protocols over Telecom Operator products.
- Access Network which minimize latency and process working for each QoS defined. Ex.: WI-FI, Bluetooth, ZigbeeIP SEP 2.0, 802.15.4e+ 6lowPAN
- All the batteries will be based on lithium or similar environment impact.
- All the elements will report a position and will be controllable remotely.
- Data warehouse access based on http+ REST in M2M & applications segments.

Periodically, ICT will evaluate if approved “local standards” could continue in the RFP processes. A team will evaluate the integration problems of new standards in terms of interoperability with existing elements (legacy) and new standards.

Consequently, this will lead to a normalized and flexible stack of standards that permits to integrate heterogeneous smart projects. Standardization is the key requirement for communicating, comparing and combining information from different devices.

Creation of a NORMALIZED Framework based in Standards at all levels allow an ordered massive construction of sensors in the streets and associate applications, based on:

- Construction Model: Powering & Housing
- Network Model for Access & Transport
- Data Warehouse Model
- Application Access Model

### 7.1.1 Target Architecture

Once the basic functions of a comprehensive smart city platform have been outlined, the next step is to develop a reference architecture:

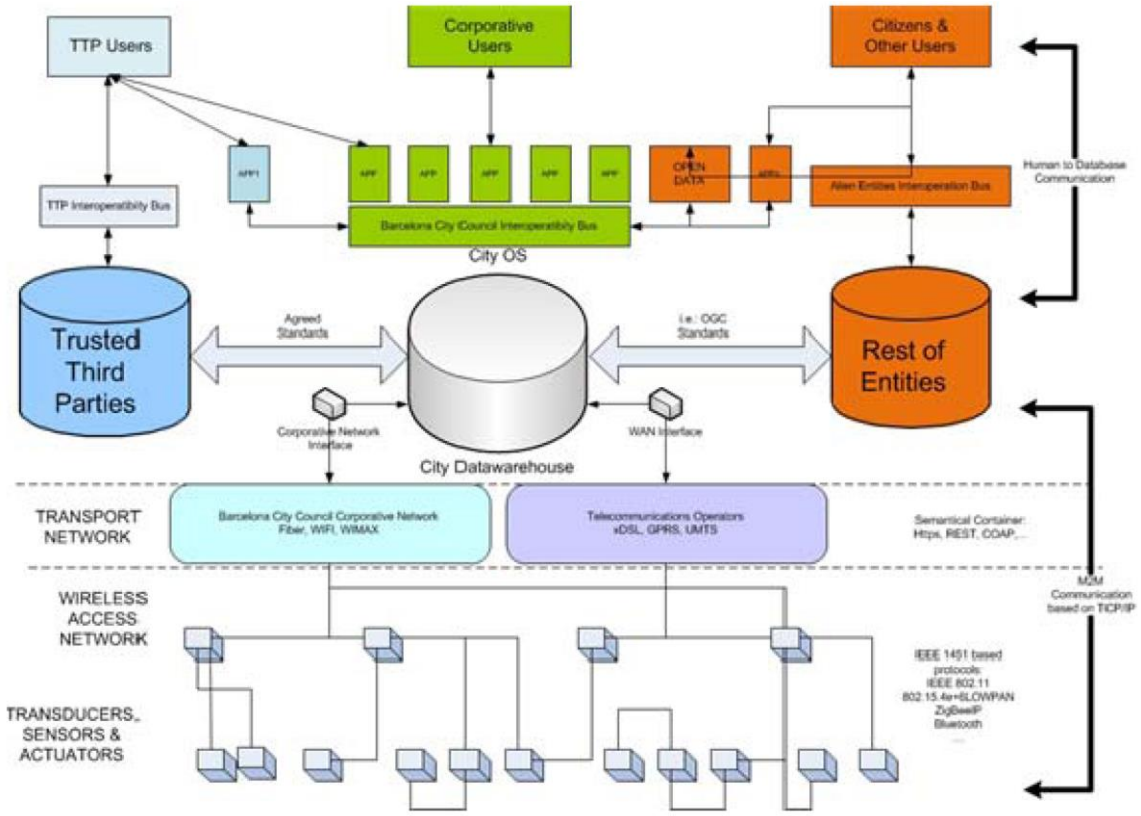



Figure 36. Reference Architecture

Taking human communication as the hypothesis is solved by operators and ICT architecture is not an issue for this section, we will evaluate different options in M2M area:

1) **Field Network**

   Area composed by Transducers, Sensors and Actuators as tools of Defined Services.

2) **Access Network**

   Link and devices involved in connection between Field Network Devices and Transport Network. This area will be wireless or wired from devices to gateways between Access Networks and Transport Networks.

3) **Transport Network**

   Links and Devices involved in connection between gateways and city Data warehouse premises.

All these options could be private or owned by the city.

## 7.2 Overview over Standardization efforts

Example of City of Barcelona involvement on Industry Standardization efforts Global standardizations bodies

**Intragovernmental Bodies**


**Other Relevant Groups**


**US and European Organization for Standardization and Certification**


**Spanish National Certification and Normalizations body**


# 8 Interoperability and Roaming

## 8.1 The Wi-Fi Roaming Ecosystem

Outside homes, people are relying more than ever on their smartphones and tablets to stay in touch with colleagues, friends and families and access resources they need such as maps, restaurants and shopping establishments and much more.

Wi-Fi networks have become widely available and already carry about 70% of the traffic generated on mobile devices[1]. Developments still in the pipeline will likely make these networks even more pervasive. Many municipalities worldwide have launched “smart city” programs that often include publicly available Wi-Fi.

1) McKinsey & Company

These and other developments will likely expand Wi-Fi coverage through new network rollouts, increased spectrum, and better technology standards.

For Services Providers (SPs) in general, there's an opportunity to harness people's familiarity and acceptance of Wi-Fi to create new services and products, encouraging additional roaming usage and revenues. A managed Wi-Fi Roaming service can greatly improve the overall user experience with regard to:

- Simplifying the connection to a Wi-Fi hotspot
- Seamless roaming between Wi-Fi hotspots (nationally and internationally)
- Better technical performance of a Wi-Fi hotspot
- Secure authentication and connection to a Wi-Fi hotspot
- Privacy for the end user
- Access to a much larger Wi-Fi network across different geographies and venue types

There are three primary stakeholders in the Wi-Fi Roaming ecosystem. Due to the communal nature of Wi-Fi, a single company is often involved in providing more than one element of the ecosystem.

Visited Network Providers (VNPs) or Wi-Fi Network Owners – Perhaps the most complex group, a Wi-Fi network is made up of one or more Wi-Fi access points. The owner of a Wi-Fi network may be content to only allow private access to their network, and not share it with roaming subscribers.

Wi-Fi network owners come in all shapes and sizes; for example, single site locations like a coffee shop venue, to multi-site locations like hotel chains or cities. There are service providers (such as BT, Boingo and Comcast) who have built Wi-Fi networks to complement fixed networks, and mobile providers (like AT&T) who've added Wi-Fi to augment mobile capacity. There are millions of one-off locations around the world offering free and open Wi-Fi, including Cities, Hotels, Coffee-shops, Airports, transportation hubs, among many other types of infrastructure. And there are aggregators like iPass that have built businesses around actively connecting and managing access to pools of Wi-Fi networks. These companies can bring millions of disparate access points into a roaming hub in a single connection.

These are the Visited Network Providers (VNPs) which provide access and Wi-Fi connectivity to subscribers.

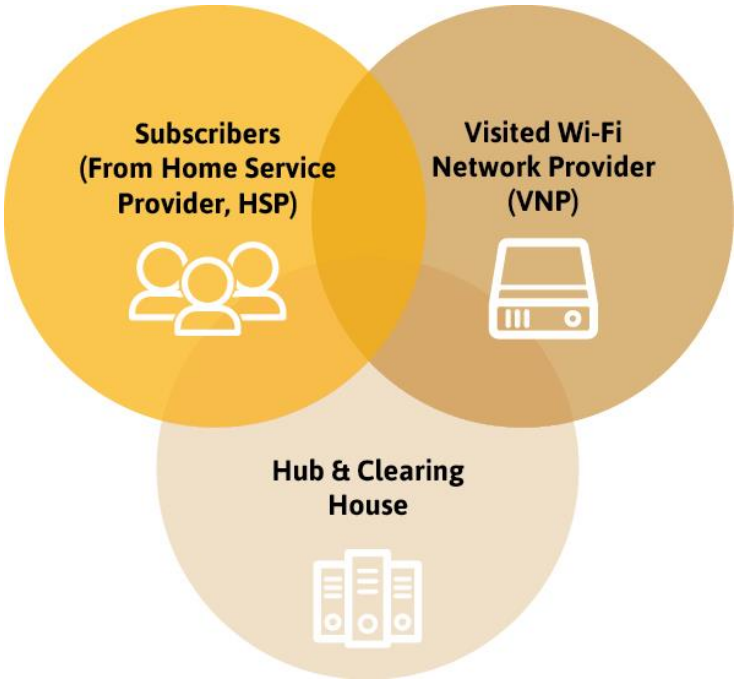



**Figure 37. Typical WLAN roaming ecosystem**

The Wi-Fi Hub provides a central connectivity point between the visited Wi-Fi networks and the home subscriber networks. Within the hub, there are two general functions –

- Inter-connectivity – maintaining information associated with each Wi-Fi access point in each Wi-Fi network, and managing the authentication/authorization process of an end-customer to that visited network back to their home network data base.
- Settlement and Clearing –accounting of usage between networks and reconciling that usage across the visited Wi-Fi networks to ensure that providers can get paid and users can get billed, if applicable.

To facilitate and standardize this process the WBA pioneered the Wi-Fi Roaming Intermediary Exchange (WRiX) specification.

Subscribers – these are the end customers who roam and ultimately use Wi-Fi managed by a Visited Network Provider (VNP). To facilitate access, the subscribers may have a downloadable app or have functionality embedded in their device, which helps them to find appropriate Wi-Fi access points and can manage the connection process. The subscribers may have an existing billing relationship from their Home Service Provider (HSP), and likely be assigned a service plan that includes roaming capabilities.

For the purposes of Wi-Fi roaming, the vast majority of subscribers are mobile-centric, with a smartphone (because it has Wi-Fi) and a SIM. Mobile Network Operators who choose to connect with a Wi-Fi roaming hub provider who can enable the appropriate subscribers to access Wi-Fi as defined in their service plan.

## 8.2 Wi-Fi Roaming Architectures

To provide Wi-Fi roaming services, the VNP and HSP must have interoperability mechanisms in place. Figure 20 illustrates the most common Wi-Fi-to-Wi-Fi roaming architecture based on the WRIX architecture as defined in WBA documentation.

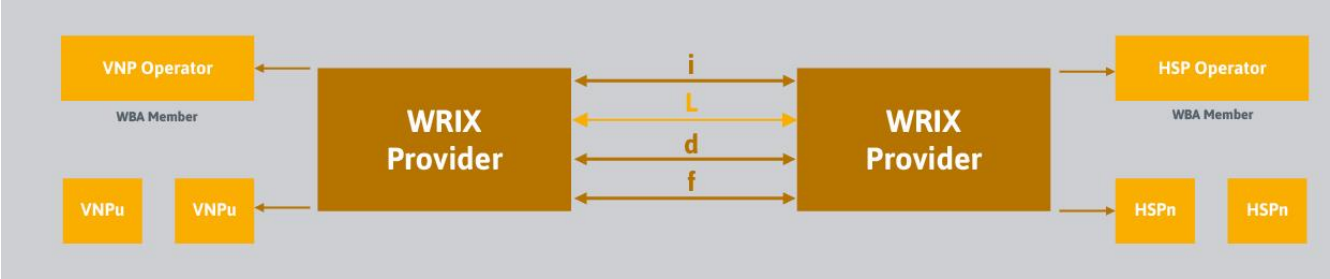



Figure 38. Typical WLAN roaming architecture

The visited network provides the connectivity to the client devices, but redirects the initial authentication of the roaming client devices to the home network AAA servers, typically via RADIUS (Remote Authentication Dial in User Service) proxy or from the Access Controller. Connection between the networks must be secured using private circuits, MPLS or Virtual Private Network (VPN) tunnels.

The authentication can be done between the home and visitor networks while the accounting and reconciliation of usage for billing purposes may be outsourced to a third party. RADIUS accounting is not lossless, so accounting records between the home and visited network providers might differ from each other. If sufficient resources cannot be allocated to compare the records and manage the discrepancies, the accounting should be outsourced to a third party.

Figure 21 does not show a policy controller, which is mandatory in some countries and for operators of a certain size. It is used to set the access policies to roaming customers and can provide feedback from both the visited and home network operators as well as the venue where the users are located.

Service Providers may have different approaches when developing a roaming strategy. There are two main scenarios available to interconnect their networks, either through a direct connection or by using a third party to facilitate that interconnection. For the latter, there could be several hybrid models from both operators using the same hub or just one operator using a hub provider (see figures 39 and 40).

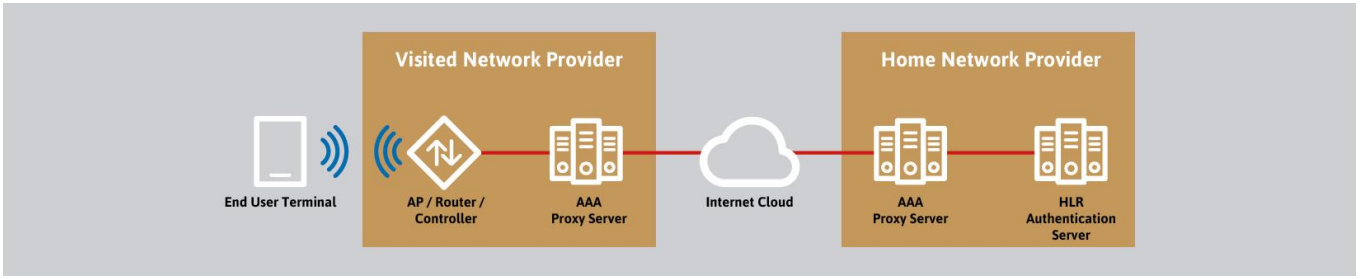



Figure 39. WLAN roaming with direct, bilateral interconnection

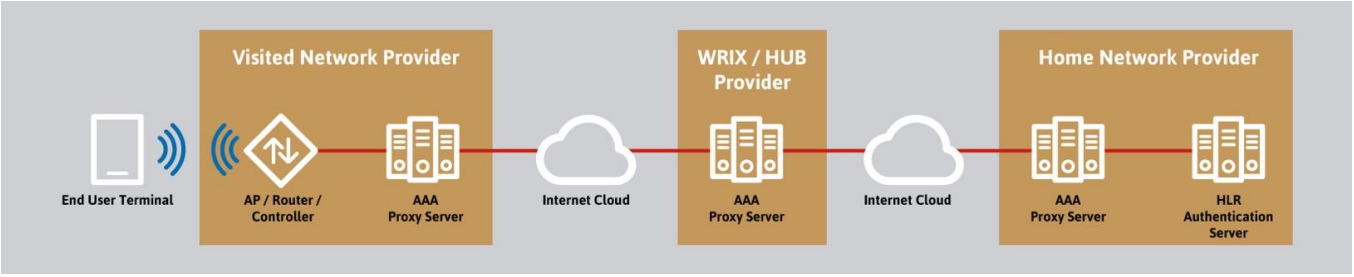



**Figure 40. WLAN roaming bilateral interconnection using a third party provider**

In a Wi-Fi roaming environment, there is likely to be a large number of relatively small visited Wi-Fi Network Providers. A hotel chain, an airport, a convention center, and perhaps other venues, may all be a part of a subscriber's Wi-Fi roaming experience. Thus, for the home network service provider to deliver a compelling experience, the broader and denser the visited Wi-Fi network, the more value for the end user.

As such, the role of a Wi-Fi Roaming Hub is quite important in enabling service providers to build and consolidate Wi-Fi footprint quickly, and delivering a compelling experience to their end users. The Wi-Fi Roaming Hub providers the following benefits:

- Consolidate Wi-Fi access across multiple networks/providers into a single 'Visited Network'
- Manage connectivity, accounting and access with and between a wide variety of Wi-Fi access networks
- Reconcile accounting and usage records between wide variety of networks and providers

To enhance the attractiveness of roaming service, a hub may propose and offer additional services to the HSP (and their end users), that are absent in the earlier arrangements, after reaching to an agreement with the HSP and VNP. It may be supplemented services unique to the host, unique not only in the literal sense, but, for example, associated with the peculiarities of the local legislation and so forth. In addition, it may be due to the technical features of the VNP network.

For more information, please refer to the WBA Roaming Technical Guidelines Whitepaper

View the WBA Roaming Technical Guidelines

## 8.3 Multi-Network Governance

Ubiquitous connectivity through mobile devices is reshaping the social life, economic activity and governance of cities. A new surge of government investment in public Wi-Fi infrastructure is occurring within a telecommunications environment underpinned by market liberal principles. Raise the issue of what role and function of cities and local governments in providing Wi-Fi infrastructure and to manage third party networks available for Wi-Fi Roaming in the city territory.

Cities may explore the development of wide grids of coverage by combining different networks through roaming services, given to citizens as a single credential that can be used in a variety of networks.

These grids can be managed directly by the city's authorities or by a third party, either one of the network provides of roaming and interoperability hubs.

Other ways of organization can be explored to create specific consortium´s or federations of networks to pursuit a common interest and facilitate the delivery of connectivity to the citizens. These approaches will help to simplify the negotiation and implementation of Wi-Fi Roaming services with entities outside the city's territory, either other cities or operators.

In NYC there are many incumbent Wi-Fi providers; the Harlem Wi-Fi network, the Alliance for Downtown New York and the Downtown Brooklyn and other business improvement districts, Transit Wireless underground subway locations, as well as the thousands of kiosks being installed on the streets. All are independent, free, public Wi-Fi networks. New York is looking at a way to make a ubiquitous footprint, to federate this group and to have them work under a policy where they would have seamless roaming in their city.

New York has more than hotspots; it has large corridors of coverage areas. What the city is doing is becoming a network operator, and beginning to take a look at where each one of these access points are. Their current standard of operation, 802.11n, 802.11ac, and then taking a look at the physical characteristics in terms of their longitude, latitude and the heights of where these access points are. They're building a real world service area and they're federating their incumbents. At the end of the day, they're creating what they call a 'Wi-Fi heartbeat.'

## 8.4 Network Performance

In a Wi-Fi roaming environment, there are likely to be a large number of relatively small Wi-Fi Network Providers. An airport, a convention center, outdoor deployment and perhaps other venues, may all be a part of a user Wi-Fi roaming experience. Thus, for the network service provider to deliver a compelling experience Service Level Agreements may be agreed and defined to establish roaming. The implementation of Performance Indicators will facilitate the harmonization of the experience for the end user and align the network performance to maintain an end-to-end quality of the WLAN roaming service between networks.

Quality of Experience must be managed by the network provider to achieve service experience levels expected by the user. This includes: network reliability that provides expected throughput targets; supported mobility across access points (AP) within the Wi-Fi network to ensure a seamless user experience and support of multi advanced service differentiation (such as the ability to support premium video) and mobile multi-media across APs. Underlying these technical attributes is the need for radio conformance to radio protocols and air interface interoperability of devices and APs.

To provide a consistent user experience and managed quality of service (QoS), the Wi-Fi network needs to be manageable by a provider using existing standards and techniques adopted by the industry. Network providers need to manage policies and to support QoS with measureable results, including in highly dense interference environments. Network faults need to be automatically detected and reported to the operator's management system.

Effective and dynamic radio resource management is essential to realize network quality. Radio resource management on a massive scale (hundreds of thousands to millions of APs) requires conformance to radio protocol standards across vendor products. Dynamic load sharing across multi-band operations is needed as well as the use of interference mitigation techniques in dense deployments. Network

providers need to manage their networks to optimize coverage, throughput and other Key Performance Indicators (KPIs).

Interoperability of management systems for the Wi-Fi network is essential in order to provide End-to-End management of the Wi-Fi network and to provide command and control capabilities from a Network Management Centre, for successful network operations to meet the network's management metrics.

Network manageability starts with standards-based provisioning of devices, APs and infrastructure. This includes auto-configuration and remote configuration methods. Network manageability includes automated troubleshooting and network optimization to help ensure reliable network performance to measureable KPIs. Load Management with optimal resource allocation are essential capabilities. Load and traffic conditions need to be reported to the Network Management Centre in a timely basis. Management capabilities to support regulatory compliance can be considered as well.

The network quality of Wi-Fi is assured with radio physical layer and protocol interface conformance to standards, effective operator radio resource management, and high levels of interoperability with certified devices, and support of KPIs.

Wi-Fi network providers should have the means to manage radio resources, including the ability to, but not limited to, manage the following list of parameters:

- Transmit power
- MCS rates
- MIMO and MU-MIMO configurations
- Beam forming configurations
- Channel bandwidth
- Maximum throughput per device
- Carrier sense thresholds
- Multi Band configuration and steering of devices, which can include dynamic traffic load sharing across bands
- Subscriber and service-driven dynamic load balancing among APs, bands and channels
- Channel assignments
- Interference avoidance and mitigation for higher density deployments

Wi-Fi network providers should also have the support and ability to collect and monitor the KPIs listed below:

- Received signal strength from devices
- Noise and interference levels
- Packet error rates and packet loss rates
- Throughput of uplink and downlink per device

- Device location
- Load threshold indicators
- Channel utilization
- Band utilization
- Rogue AP detection
- Neighbor AP detection
- Delays, latencies and jitter for traffic uplink and downlink

## 8.5 WRIX Standard

WRIX (Wireless Roaming Intermediary Exchange) is a set of service specifications published by the Wireless Broadband Alliance to provide a framework for Wi-Fi interconnection, data clearing, financial clearing and the exchange of Wi-Fi location information between Service Providers. The purpose of the service specification is to standardize both technical and business processes between Wi-Fi Roaming Partners.

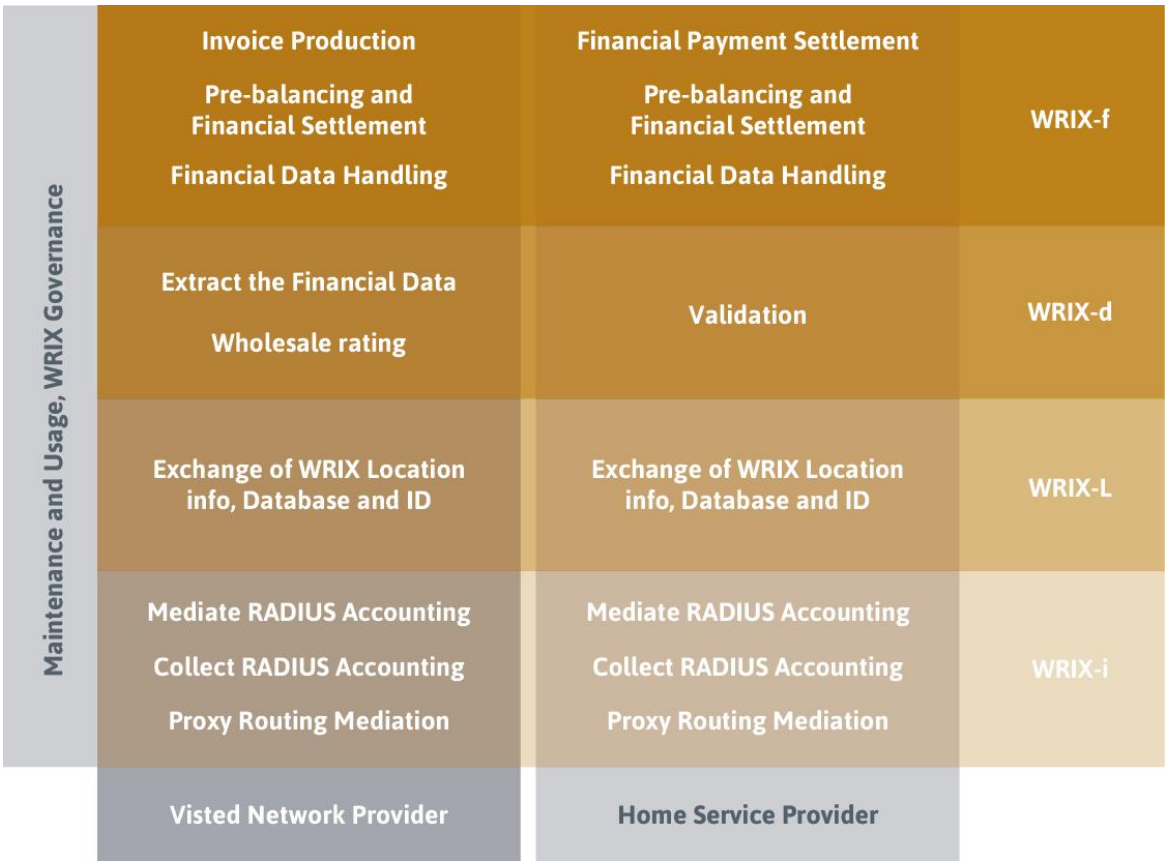



**Figure 41. WRIX framework**

The WRIX (Wireless Roaming Intermediary Exchange) is comprised of the four specifications listed below. The recommendation is for Service Providers to utilize all four of the specifications. However, it is acceptable for different partners to utilize the specifications only as guidelines, or part of it, when creating and maintaining Wi-Fi Roaming partnerships.

Specifications:

- WRIX-I : RADIUS Interconnection Specifications
- WRIX-D: Data Clearing Specifications
- WRIX-F: Financial Settlement Specifications
- WRIX-L: Locations Feed Formation and File Exchange Specifications

The full suite of the WRIX Specification documents is available here:

View the WBA WRIX Specification Document

### 8.5.1 WRIX-I

The WRIX-I specifies the interconnectivity, authentication and accounting processes between Wi-Fi Roaming Partners. Interconnectivity is established and maintained through either Private Leased Circuits (IPLCs) or IPSec VPNs. When selecting an interconnectivity method the performance and security considerations must be weighed versus cost. WRIX-I explicitly specifies the use of RADIUS authentication, authorization and accounting (AAA) as the transport of requests between the VNP and the HSP. This enables the support of a vast range of authentication methods including WiSPr, EAP-SIM, EAP-AKA, EAP-TLS, and EAP-TTLS. However, the VNP and the HSP must agree bilaterally to which method will be used.

There are three potential parties identified in the WRIX-I Specification:

- HSP: Home Service Provider
  - Maintain connectivity linkage
  - On-line proxy routing for RADIUS messages, sent to the correspondent WRIX-i (HSP)
  - Collect raw RADIUS accounting records generated by the proxy routing
  - Mediate raw RADIUS accounting records for wholesale billing
  - Send those records to the WRIX-d (HSP).
- VNP: Visited Network Provider
  - Maintain connectivity linkage
  - Proxy routing mediation for RADIUS messages.
  - Receive raw RADIUS accounting records generated by the proxy routing

- Optionally mediate raw RADIUS accounting records for reconciliation of wholesale billing and send those records to the WRIX-d (HSP)

- HUB: An optional intermediary between the HSP and VNP
  - Perform duties on behalf of either the HSP or VNP

WRIX-i supports the implementation of Key Performance Indicators (e.g. RADIUS Server Uptime / Availability or IP Connectivity) to provide guidance in negotiating a Service Level Agreements (SLAs) and maintaining across the services the quality of the WLAN roaming between networks. Supports the implementation of Incident Severity Definitions as well.

Please refer to the WRIX-I Specification Document for further **information**.

### 8.5.2 WRIX-D

The WRIX-D is the data clearing specification of the Wireless Broadband Alliance. Within the specification are clearly defined roles and responsibilities between Wi-Fi Roaming Partners and the timeline of activities. WRIX-D utilizes the records generated from the WRIX-I platform to perform service validation that protects both Wi-Fi Roaming Partners and prevent any potential disputes during financial settlement.

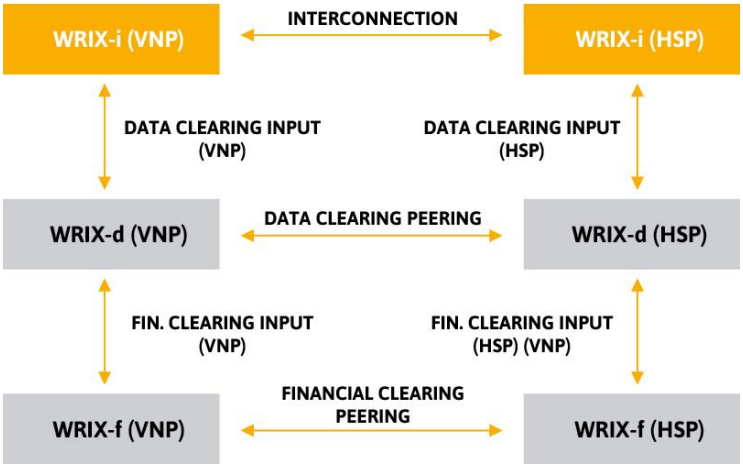



**Figure 42. WRIX typical flow**

The process begins by the VNP processing UDRs (usage details records) generated from the WRIX-I RADIUS AAA system to validate, perform exception processing (if necessary) and rate the records. After processing the rates, UDRs are transmitted to the HSP. The HSP receives and processes the rated UDRs. Upon successful UDR processing the HSP transmits a summary financial data (INPUT SFD) to the VNP as an acknowledgement to record acceptance. The VNP uses the SFD to generate an invoice for the HSP. A HUB provider may perform duties on behalf of either the VNP or the HSP.

Please refer to the WRIX-D Specification Document for further **information**.

### 8.5.3 WRIX-F

WRIX-F is the Financial Settlement specification of the Wireless Broadband Alliance. By proceeding after the WRIX-D processing, where records are either validated and rated or follow an exception processing method, the WRIX-F ensures that a smooth billing, payment and receivables process occurs every time. The WRIX-F specification includes detailed reports and a set timeline, which is displayed in this section.

WRIX-F begins by the VPN sending a Summary Financial Document (SFD) to the HSP. The SFD summarizes the traffic usage that occurred on the VPN's Wi-Fi Network by end-users of the HSP. The SFD is used by the HSP to assist with creating a net settlement position between the two Wi-Fi Roaming Partners. Alternatively, a HUB can be used to either deliver all of the SFDs to each of the HSPs on behalf of the VNP or to receive all of the SFDs from the VNPs on behalf of the HSP.

Once the SFDs are processed the Net Payment Reports (NPRs) are created and shared by both parties. The NPR summarizes the payables and receivables between the Wi-Fi Roaming Partners. Key data elements include settlement type, Net Payment, Net Payee, Net Receiver and currency. A HUB provider can act on behalf of an HSP, VNP or both.

Upon acceptance of the NPR between the Wi-Fi Roaming Partners the Wi-Fi Operator that is in the Net Payee position will invoice the Net Payer (debtor) based on the NPR values. In case mismatches are identified in the invoice the Net Payer can raise a dispute. In case of mismatch the disputes rules and limit levels of how to handle the payments are specified in the bilateral agreement. Note: The settlement cannot be carried out in case the invoice is not received. A HUB may act on behalf of either or both parties.

Once an invoice is created the debtor pays the Net Amount according to the method as agreed upon in the bilateral agreement.

Please refer to the WRIX-F Specification Document for further **information**

### 8.5.4 WRIX-L

WRIX-L is the Locations Feed Formation and File Exchange Specifications of the Wireless Broadband Alliance for the sharing of Wi-Fi Hotspot Location information. The use of accurate and up-to-date information is crucial to ensure a high-quality experience for end-users and to maximize the revenue opportunity associated with network usage. Poor quality or outdated location information will result in unsatisfied, frustrated end-customers of the HSP and missed revenue opportunities of the VNP.

The WRIX-L specifies mandatory and operational data. Mandatory data includes critical data elements such as provider information, location information and SSID. This information is provided by the VNP so that the HSP is able to configure the end-user clients to display Hotspot location information and to configure the device to connect to the VNP Hotspot once the end-user is within range.

Often a HUB provider will receive WRIX-L data from all VNPs of a HSP and aggregate the data into one file. This offloads burden from the HSP from receiving data from many sources and provides a single location for all Hotspot information.

There are three potential parties identified in the WRIX-L Specification:

**HSP: Home Service Provider**

- Provides a location file
- Distributes to roaming partners

**HSP: Home Service Provider**

- Receives location file
- Uses the location file in connection client software distributed to subscribers

**HUB: An optional intermediary between the HSP and VNP**

- Act on behalf of either the HSP, VNP or both.
- Provides a centralized repository to receive or distribute WRIX-L information

Please refer to the WRIX-L Specification Document for further information.

## 9 National Institute of Standards and Technology Public Wi-Fi Supercluster Blueprint


The National Institute of Standards and Technology (NIST), a non-regulatory agency of the United States Department of Commerce, convened a program known as the Global City Team Challenge. The GCTC brought together leaders from industry, government, and academia to form a collaborative platform for the development of smart cities and communities.

The GCTC consisted of project groups called "Action Clusters" and strategy groups called "SuperClusters". In 2017, David Witkowski, Executive Director had the honor of being the Lead Co-Chair for the GCTC Public Wi-Fi SuperCluster (PWSC).

They were tasked with two things; create a blueprint for public Wi-Fi, and present this blueprint at a conference exhibition.

The document "Public Wi-Fi Supercluster Blueprint" is available for download

View the "Public Wi-Fi Supercluster Blueprint"

The blueprint was structured with a practical, modular approach in mind. Each chapter focuses on a specific element in the Public Wi-Fi deployment process:

- Introduction to Public Wi-Fi Use Cases
- History of Public Wi-Fi

- Funding and Business Models
- Legal Issues
- Marketing & Outreach
- Procurement
- Technology Strategy & Policy
- Project Management
- Real-World Case Studies
- Appendices

**Historical Perspective on Public Wi-Fi**

The dream of public Wi-Fi isn't new. In the past two decades, many cities have sought to provide high-speed internet to their community, and give consumers a free, public option for internet service. In some cases, the systems have been used to support tourism or shopping districts.

In recent years as the issue of Digital Inclusion has become more evident, public Wi-Fi is seen as an option to close the digital divide, shrink the homework gap, and connect the unconnected. It's not hard to see why the concept has remained so popular over the years. Yet a model for consistent success of these systems remained elusive – some systems flourished while others failed. The Public Wi-Fi SuperCluster Blueprint attempts to rationalize these inconsistencies and provide guidance towards a more consistent model for success.

**Blueprint Process**

The PWSC team chose to analyze the problem by conducting a survey of local governments, then analyzing the survey results for trends. We received nearly four dozen responses from local governments across the United States. We convened a full-day workshop where nearly six dozen leaders from industry, local government, and academia participated in an intensive set of facilitated breakouts to analyze the survey data and suggest theories to account for the success of failure of public Wi-Fi. Each facilitator was also a member of the PWSC core leadership team, and was selected for their expertise in use case analysis, funding and procurement, legal, marketing, technology, and project management. These facilitators were then tasked with authoring a chapter on their area of expertise. Two co-editors then pulled the document together into a cohesive whole.

**Use Case Analysis**

They found that use cases and outcomes varied widely by city, but in most cases, there were common goals: Improve overall city efficiency, citizen engagement, and quality of life; support economic development, increase digital inclusion, and enhance city services and efficiencies. These use cases represent the core reasons and goals for executing a public Wi-Fi network deployment.

It was also evident that successful deployments were those where the local government was the "anchor tenant" on the system – in other words, the local government used the network for cost reductions and to increase operational efficiency. In these use cases, public Wi-Fi networks were able to sustain because the revenue model was based on internal savings, not external income.

**Revenue Models**

Public Wi-Fi which relies on payments from users has, in our analysis, not been successful. Revenues in these cases always falls short of expectation, which then leads local government leaders to abandon the project as a failure.

In contrast, when internal cost savings and increased efficiencies are counted as "revenue" these systems can appear quite compelling.

Consider the case of a downtown shopping district or tourist area where the city wants to implement network-connected parking meters. The benefits of these are more satisfied users, easier revenue accounting, the ability to know how many spaces are in use, etc. Connecting these parking meters via cellular data can be expensive in terms of ongoing monthly costs, and hard-wiring each meter into a network is cost-prohibitive. Connecting the parking meters via a public Wi-Fi network allows the city to save both up-front and ongoing costs.

In other cases, the funding model is based on the notion that Wi-Fi is a public good, and that there's no direct return on the investment. This is especially true in larger cities with disadvantaged and at-risk populations. Some revenue models involved the collection and monetization of anonymized aggregate user data i.e. user movement patterns, restaurant choices based on time-of-day, length of visits, etc. however this was surprisingly not as common as we expected.

**Legal Issues**

They found that legal issues around public Wi-Fi are often not well understood, and the approach to managing these issues is not consistent. This leads to a confusing mix of end-user agreements, usually notified through hard-to-use captive portals. To be fair, the amount of illegal content accessed on public Wi-Fi networks is fairly high and while technology solutions are available to mitigate this, it's a complicated and never-ending battle to manage.

**Technology Strategies**

A variety of technology decisions need to be made to effectively deliver good public-Wi-Fi service, while supporting the current and future applications that cities and towns are seeking to deliver. While Wi-Fi itself is well understood and widely deployed, modern public Wi-Fi deployments, which are often outdoor and in locations where there are no pre-existing networks, can be more complicated than traditional in-building networks. As a result, cities planning public Wi-Fi deployment will likely need to support a growing range of new applications and face many technological decisions in the process.

We believe it critical that cities develop an overall strategy to guide their Public Wi-Fi deployments. This includes a clear understanding of the goals for the deployment, metrics for determining success, and a baseline for measurement. Elements for these baselines and metrics include:

- Target Performance – typically determined by the data rate of the connections.
- Bandwidth Shaping & Rate Limits – used to ensure that a small number of users do not overwhelm the network's capacity with excessive usage.
- Service Tiers – determines whether all users get equal service/performance, or whether certain users will receive higher class service.
- Time of Day Usage Controls – deactivating public Wi-Fi at certain times or on certain days may be desirable to prevent loitering or ensure that public parks are not used overnight.
- Customer Support – many public Wi-Fi systems are provided "As-Is" with no way for users to request technical support. However, if the public Wi-Fi system is intended to connect merchants or other businesses, technical support may be needed.
- Security – most public Wi-Fi networks operate in an "open" configuration to avoid having to provide SSIDs and passwords. However, this place the burden of security on the user and may expose them to hacking.
- Privacy – collection and monetization of anonymized user data can be used to offset costs of a public Wi-Fi network, but this can lead to concerns about privacy. We recommend that providers of public Wi-Fi be very transparent about data collection, if it's done.

**Project Management**

The GCTC Public Wi-Fi Blueprint contains an extensive section on project management, including milestone examples, templates, and worksheets that can be readily adopted by agencies planning to deploy public Wi-Fi.

**Case Studies**

We present in the GCTC Public Wi-Fi blueprint case studies from 10 agencies that deployed public Wi-Fi. Sources for the case studies include survey results and interviews with the IT leadership from those agencies.

## 10 UK Smart Cities Index 2017

The second release of the UK Smart Cities Index which was commissioned by Huawei from Navigant Consulting, Inc captures an interesting set of matrix to assess the success of city programs towards becoming "Smart" .

This report builds on and significantly extends the UK Smart Cities Index 2016. Since that report was published, there have been a series of global and local political changes reshaping the political and economic landscape in ways yet to be clear. This has only increased the focus on the role cities play in addressing some of the biggest challenges facing the country and its communities. In parallel, the momentum behind the development of smart or future cities continues to grow as UK cities look to exploit technology to address their social, economic, and environmental challenges. This interest in technology is accompanied by programmes for innovation in governance and process that will embed innovation at the heart of city policy.

**Emerging Trends**

The momentum behind smart cities is reflected in a growing understanding of what is required to accelerate the adoption of digital technologies. The research for this report identifies five key developments:

- **Bridging the gap between smart city programmes and strategic city priorities:** Cities are building the links that will embed digital innovation in frontline services.
- **Supporting the emergence of city platforms:** More cohesive strategies are being developed for the deployment of new technologies, including big data analytics and citywide Internet of Things (IoT) solutions.
- **Strengthening regional perspectives:** As the extended scope of smart cities is recognised, smart city programmes are developing collaboration networks across combined authorities, county authorities, and regional agencies.
- **Expanding the partner ecosystems needed to deliver a smart city vision:** The increasingly important role that local universities are playing in shaping and developing urban innovation programs is one notable development.
- **Developing more integrated approaches to city issues:** A growing number of projects recognise the interconnection between transport, health, energy, and housing, for example, and the need to assess the impact of innovations across these traditional siloes.

These positive developments are also leading to fresh assessments of the challenges facing cities. The impact of austerity measures and cuts in local government spending continue to be an important factor in shaping city polices, priorities, and the ability to adopt technical and organisational innovations. However, the most commonly cited challenges to the adoption of new approaches and new technologies

are the ability and the appetite of local government to accept and manage the risk associated with innovation – in terms of the financial, organisational, cultural, and technical barriers presented.

**Evaluation Method**

The 20 cities were selected on the breadth and depth of their smart or future city strategy and specific programmes in areas such as digital innovation, social care, urban mobility, energy, education, and sustainability. The assessment also looks at the extent of their partnerships and collaboration with other agencies and the private sector. A detailed comparison was made of the top 20 cities to identify the current leaders and their closest challengers.

The evaluations in this report are based on Navigant Research's corpus of smart city research; public documents on city strategies, projects, and performance; interviews with city leaders and project teams; and interviews with other key stakeholders in the development of smart cities from the public and private sector.

**Evaluation Criteria**

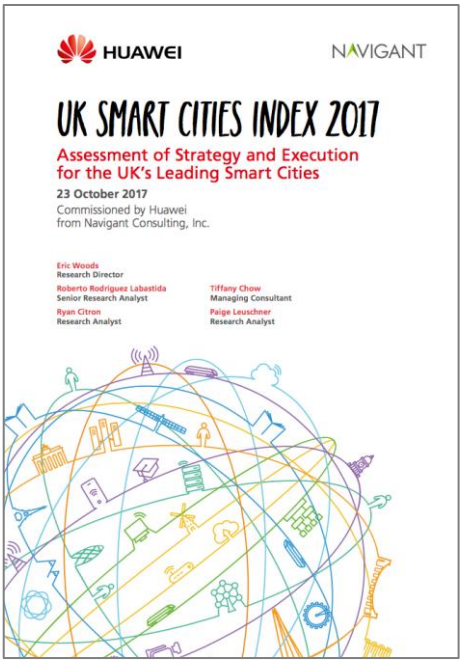
The city evaluations for this Index are based on two dimensions: Strategy and Execution. The Strategy dimension assesses each city's vision, goals, and objectives as they relate to its smart city programme. The Execution dimension assesses the city's actual achievements, from initial projects to full- blown deployment of innovative technologies and services.

Each dimension is split into five evaluation categories. The evaluation categories for the Strategy dimension are:

- **Vision:** Assesses the clarity, comprehensiveness, and depth of the city's smart or future city strategy.
- **Digital Innovation:** Evaluates a city's strategy to develop and exploit digital technologies and services.
- **Service Innovation:** Examines a city's strategy for innovations in local services that exploit improvements offered by smart technologies.
- **Sustainability Plans:** Assesses a city's sustainability strategy and the explicit targets set for energy consumption, greenhouse gas emissions, and related goals.
- **Stakeholder Engagement:** Examines the range of city stakeholders involved in the development of the smart city strategy.

The evaluation categories for the Execution dimension are:

- **Implementation:** Assesses the city's overall progress in translating its strategy into action based on the number, range, and extent of projects implemented to date.
- **Digital Delivery:** Evaluates progress on implementing the city's digital strategy, including pilot projects, smart city demonstrators, and full-scale projects.
- **Service Delivery:** Evaluates progress on implementing service innovations defined in the city's smart city strategy.
- **Environmental Impact:** Looks at achievements against sustainability targets and implemented environmental and sustainability programmes.
- **Community Reach:** Assesses engagement across multiple communities and stakeholders and the extension of projects into the wider city region.




Navigant Research scores the cities in the UK Smart Cities Index according to four categories; Leaders, Contenders, Challengers, and Followers

The full report can be downloaded here:

Download the Full Report

## 11 Public-Private Partnerships Business models

A general concern for cities is the limited budgets that they often have when they are thinking about infrastructure projects, whether it's about roads or energy or telecommunications, there can be difficulties in getting the funding to develop a transformational approach. Public-private partnerships, they can make sense from a financial perspective. It can help relieve some of the burden on cities in adding this infrastructure.

According to the United Nations, some of the main objectives of the PPP for Cities are:[2]

- **Identifying and disseminating good practices internationally**
- **Creating spaces of debate among companies, administrations and experts from all over the world on specific topics**
- **Creating working standards for managing PPP projects**
- **Helping governments develop public-private partnership projects in the sphere of cities**

2) Public Private Partnerships for sustainable and smart cities UN

- **Conducting research**
- **Designing training strategies in the sector for state and regional governments, especially in countries with less experience, and fostering the exchange of knowledge with countries with more experience in PPPs**
- **Providing specialized training in PPPs**

Work should be done under the **Sustainable Development Goals, mainly 11th "Make cities and human settlements inclusive, safe, resilient and sustainable"** and **17th "Revitalize the global partnership for sustainable development"**


Public-Private Partnerships (PPPs) aim at financing, designing, implementing and operating public sector facilities and services.

Their key characteristics include:

a) Long-term (sometimes up to 30 years) service provisions;

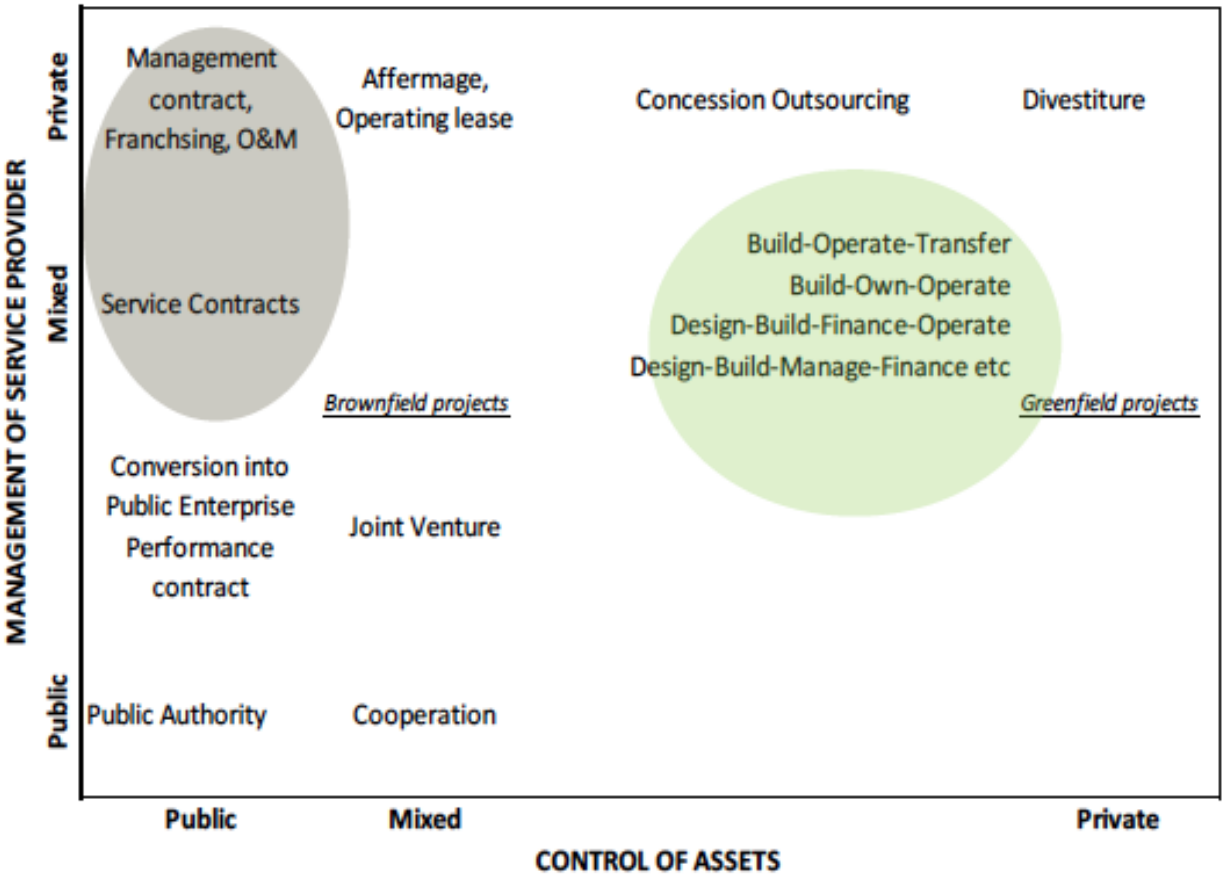
b) The transfer of risk to the private sector;

c) Different forms of long-term contracts drawn up between legal entities and public authorities[3]

Download the Guidebook on Promoting Good Governance in Public-Private Partnerships by UNECE here:

Download the Guidebook

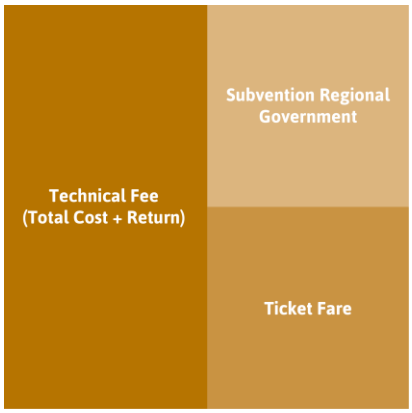
3) Guidebook on Promoting Good Governance in Public-Private Partnerships. UNECE




Source: Delmon, J. (2010), Understanding Options for Public Private Partnerships in Infrastructure, Policy Research Working Paper 5173, World Bank.

**Key Issues**

- Governance
- Financing
  - Lower dimension of projects (investment and revenues
  - Need to innovative models
  - Use of value of land and taxes as a financing instrument
- Citizenship participation
  - Need of considering citizens as another agent in the equation
- Sustainability
  - Need of efficient use of resources




**Distinctive features of European Cities, issues affecting the implementation of PPP's**

- Difficult Governance results that are the results of highly participative social movements and groups of interest
- Existence of (old) infrastructure
- Urban design (high density, services and infrastructures)
- Culture heritage and pool of research centers
- Governance

## 11.1 Metro de Sevilla

First tramway in the city, Greenfield project. 18km, 21 metro stations, 4 Cities (230,000 inhabitants)

**Delivery Mode:**
Build-Design-Finance-Operate-Transfer (BDFOT)

Construction start; January 14 2004. Planned end construction period. June 2006. Actual construction end April 2 2009. 2.9 years overtime.

**Project Fails**

- Draft project
- Underestimation of costs (Construction + rolling stock): 360€. Award 428MM€ (lowest bid) Actual 730MM€ (+70%)
- Delays in construction (2.9 years late)
- Advisory Committee approving contract modifications not independent from Ministry of Public Works

- Electoral timing

Initial construction "award" cost 382€. Final 680MM€ which is + 78%

Additional cost for public administration including operation was + 75% 1.093MM €

So bad governance implied higher cost for the taxpayer

Who pays the bill?

## Key Issues: Brownfiled – Technical Expertise

### 11.2 Barcelona GIX – Integrated Management of Municipal IT Networks

Brownfield project. Active & Passive Networks of Barcelona City Council (fibre optic and Wi-Fi)

**Project Type:**
Operate networks, until then managed separately under a single management contract

**Deliver Mode:**
BOT. Project Developer: Tradia Telecom (100% owned by Cellnex)

**New Business Model**

- Outdated infrastructure for new challenges: Smart Cities
- Integration municipal fiber optic and Wi-Fi
- Private management using PPP:
  - Higher efficiency in management
  - Commercialize spare capacity (incentives)

Using PPP in brownfield projects allow for public savings and business expansion

- Better service
- Lower cost

## Key Issues: Innovation

## 11.3 Velb' Paris. Project: Large scale bicycle sharing program

20.600 bicycles and 1.450 stations

**Delivery Mode:**
BFOM

**Location:**
Paris + 30 suburban municipalities

- New sustainable public transport. Reduction of Co2 emissions
  - Billboards for Bicycles – New Business Model


from private transport to public service using private funds

**What have we seen?**

- Governance; Strong governance with independent committees for a proper contract management and cost control
- Brownfield; Private firms may improve efficiency in existing infrastructure of they have the right incentives
- Innovation: New business models can help to provide public services without any cost for the administration

To be successful in developing Public-Private Partnerships, there must be a long-term viable business model. Risk-sharing is a relevant key component for both entities, both the city and the private sector.

The private sector, especially technology companies, are used to taking on some level of risk, because any kind of new innovation, until it's been proven at scale, is going to have some inherent risk.

That's something that could be a little more difficult on the government's side, because a city's perceived risk of failure seems higher to a lot of people within the government.

It's the difference between a venture capital type approach where you're trying a lot of things and hoping that the ones that succeed, succeed so well that it makes up for any failures.

From a government perspective, failures tend to be a little more painful and can be a challenge to find the right balance.

PPP are highways of innovation for cities; the more the public and private sector can partner on these types of challenges, the greater chances for truly innovative solutions to be the result. Whether that's a model that just involves start-ups getting exposed more closely to the key priority areas for the city government.

Those are some of the hurdles of adoption that has been evident for the past several years, and in the United States there is some positive movement with the federal government getting involved and helping to drive smart city initiatives with some special funding. Then the private companies that are stepping up to basically make it more palatable for cities to procure solutions and as technology advances and costs goes down, I think that will help drive adoption as well.

There is more and more discussion around public private partnerships in countries like the US and there are many of them that are loosely formed. They might not be formalized, but you will see, for example, in the city of Atlanta, you'll see that AT&T is working very closely with the city of Atlanta, with Georgia Tech as a research university, with Georgia Power and Southern Company that's a large utility and other businesses in the area, in order to drive value for the citizens of the region. It may not be a formed, public private partnership, but that in essence is what a public private partnership is, bringing those parties together and then of course, engaging the citizens.

Another example is a public private partnership in Dallas. The Dallas Innovation Alliance, or the DIA, has managed to pull together city leadership, the CIO and mayoral level, some large companies, (such as AT&T) as a foundational member and then smaller start-ups in the ecosystem. On regional level, there are real estate developers, the chamber of commerce and the business improvement district.

This PPP enables the creation of an environment of learning faster than the city itself could, primarily because it does not need to adhere to the same procurement policies. At the end of the day, what you are going to see is that some services will be procured directly from the city in a traditional manner and will need to be paid for through taxpayer dollars, or you will see public private partnerships potentially raise some money that could be used to drive issues around health, human services and socioeconomic opportunities.

Another good example is the franchise agreement between a consortium of companies in New York City. NYC is unable to have a long-term roll-out of fiber across the city to enable a network of gigabit Wi-Fi hotspots (between 7500 and 10000 over the next ten years) at no cost to the city or the taxpayers. The unique thing here is that the city saw this opportunity of unused, underutilized assets, and also had a contract vehicle in terms of the franchise agreement, in order to find a private sector partner to implement this.

Certainly, collaboration is not always easy. In the case of New York, what helped is that there was an ongoing dialogue between the public and private sectors that went back several years, to even before the first RFP was written, and there were other ways of engaging with the private sector. There was a design competition called Reinvent the Payphone several years ago where there was a call for creative

ideas from a design perspective from the private sector. This helped to inform the city on what the potential could be for that particular telecommunications asset.

With the City of New York, there was another development called Urban Tech NYC, which was a set of programs that help connect start-ups to some of the key challenges the different city agencies identified, and then support the companies through incubator programs, mentorships, and/or pilot opportunities. This leads to a smaller gap between people that are working in the start-up world and the people who are within the city looking for solutions, while accelerating innovation and development of Public-Private Partnerships between the City of NY and start-up companies.

## 12 Big Data: Challenges, opportunities and benefits for Cities

Cities are looking to the Big Data opportunity to enable public agencies to better anticipate citizens' needs, improve delivery of services, and reduce inefficiencies.

Increasingly, we have seen cities embarking on national-level data initiatives. The objective is to make both public and private data sets available to companies to build new and innovative solutions to create a smarter city. Big data is one of those opportunities that is as much cultural as it is technical.

What we see is the promise of big data where we can gain insights and make better decisions as an organization and as a community.

What that involves though is, at maturity level 1, where we have been is we to publish a lot of information for transparency.

It's not curated well, but there's basic information that people can have access too.

A step further involves some regional collaboration where we can push out information in a curated way that's consistent, so that we can make some decisions and gain some insights, not just about ourselves as we see ourselves, but as peers, as other service providers, as well as the information that we're getting from the communities we serve.

That broader and richer data set is what we see as the next value point. From there, the third level and second can be interchanged.

Cities have to develop that approach and culture in their organization to be a data driven organization. That means teaching cities how to be a good data scientist? It is not too farfetched to say that someone misreads something, and makes large decisions incorrectly, which can lead to a major negative repercussion for a long period of time at local and state government levels.

We have to make sure that we're doing the right things and we can sustain that work, and that there's enough quality in that work. It's not just that there being lots of data out there, but that we are also interpreting it well and using it well and validating that use.

The major challenges and the benefits that cities have on Big Data is that, when it works, it's beautiful. With predictive policing, for example, you can make sure that you read situations and your police department is there to intercept and stop potentially major crimes.

When looking at high volumes of data is in a utility system, a number of questions can arise. Are we managing the flow? Are we using electricity correctly? Are we limiting the amount of water we're wasting? Is the product and the testing of high quality? Are we're doing that regulatory reporting?

All of this is essential to what Cities do. Cities are having so many data inputs that the fourth level of maturity allows for a clear understanding of the entire organization and community. That raised the issue for the cities as well, in terms of if they not only need to align within the city agencies, but even beyond the city, almost at a county level or a state level interaction with other cities.

It highlights the importance of having a wider partnership and alignment, even beyond the city.

| | |
|---|---|
| **Level 4** | Have a clear understanding of your entire organization and your entire community, and ensure that you're looking at the right data so that you make your way out of swimming in information to really getting high value information that your organization knows how to read and knows how to interpret and orient their decisions around. |
| **Level 3** | Develop ourselves to be a good data scientists. It's not about being able to deliver lots of data anymore but that cities are able interpreted it well and using it well and validating their own use. Focus on making sure that the city is doing the right things and can sustain the work, and that there's enough quality in that work |
| **Level 2** | Focus on wider collaboration to deliver information in a curated and consistent way. Used data to make some decisions and insights, not just about ourselves and all we see as ourselves, but as peers, as other service providers, as well as the information that we're getting from the communities we serve |
| **Level 1** | Provide basic information that people have access to, the main focus which is publishing information for transparency |

**Table 12-1: Level of Cities Maturity to use Big Data**

Cities have different approaches in terms of the big data, such as a NIST or ANSI approach, saying, "Here's a methodology and structure and approach to manage big data and handle security, but also make yourself consistent enough that there can be a sharing of data.

There can be consortiums, like the CCAB, where we say, "Here's an approach and a blueprint that will allow us the chance to become consistent and to gain steam?"

Part of the reality is also creating that culture and organizational capacity. There's an educational piece that we can't neglect, which is how we encourage our academia, our certification programs, to create the educational material that's going to allow people to do smart cities, connected communities and big data.

A lot of these terms are types of amorphous brands; they don't mean much, or they mean something different to a lot of people.

What are the skills that are out there, and how can we create those development channels to create those skills and programs that help us hire and recruit the people who are going to help us make the next leap?

There is a big divide that exists right now, there's a many people trying to figure this out separately instead of together.

The issue of data management raises several questions of ownership and access. Those are real concerns, same as that of a connected smart city. Where do Cities put security? Where do Cities put

redaction? Everything from video data capturing children, or health events, if cities have cameras on their officers and firefighters, to surveillance and security cameras, cities have to manage all this data correctly. Having social security information or other identifying information that cities use to coordinate services with partners, security and privacy must be implemented properly.

If cities can find a good way to master data management, there is potential for a strong influx of benefits. Cities will be able to coordinate better, resource usage can be improved, and municipal services can be as high-quality as possible.

The way cities manage this is as much of a question of developing that culture inside their organization as it is working outside their organization.

The question is, how can data sources be properly coordinated and curated? We can coordinate our access to it, but also create an ecosystem where the academia and businesses can tap that data in a safe way and gain insights that we don't necessarily have when it is on its own.

These strategies must work through all departments – from the planning department, to the public works department, to IT, economic development groups, regulatory groups, etc.

The strategies for cities both smart cities and big data, are going to have to work from the planning department to the public works department and engineers, to the IT department, to the economic development groups, to the regulatory groups and planning, building, and permitting. With the big data piece, it can also extend into that regional, national, global world, to create those data links, make sure they're high quality, and to create that ecosystem that's going to help everyone do better.

Cities in general are interested in big data opportunities, especially from that high-level perspective, but depending on the city or who we're talking about in the city, the approach can be different.

In summary, the benefits and challenges for cities form the Big Data approach are the following:

| BENEFITS | CHALLENGES |
|---|---|
| • Extraordinary transformation will be made possible by data, the "new oil" of the 21st century. Data analytics uses large datasets to reveal hidden patterns, important insights that can be used for decision making. Technology advances in areas like machine learning, text mining and greater emphasis in predictive modelling and statistical forecasting can help organizations make sense from the data gathered, and see trends based on history, together with real-time data, to intelligently support decision making<br>• Being a connected city coupled with powerful computational technologies, data analytics can be a competitive tool that enables businesses to draw sharper insights into their customers and operations. It can make our businesses smarter, more productive, thereby powering our future economic growth as the global digital economy grows and businesses need to better understand their customers to stay relevant amidst fiercer business competition and savvier consumers. Analytics and data management will, therefore, be the cornerstone enablers behind industry transformation.<br>• Data-driven innovation can bring about significant benefits, for example, in enhancing resource efficiency and productivity and economic competitiveness. A report by the Organization for Economic Co-operation and Development (OECD) indicated that firms using data-driven innovation had raised productivity faster than non-users by around 5-10%. | • Big data requires new, innovative and scalable technology to collect, host and the vast amount of data to derive real-time useful insights for urban planning. Cities must understand what insights they need to make good strategic and operational decisions.<br>• To extract value from big data, it must be processed and analyzed in a timely manner, and the results need to be available in a way that can effect positive change or influence decisions. The effectiveness also relies on a city having the right combination of people, process and technology.<br>• Challenges also lie in unlocking data from private organizations. Private organizations may resist participating in such data initiatives due to competitive or privacy reasons. The release of data sets outside of their organizations could expose individuals and businesses to risks, such as reputational risks, loss of control over confidential information and privacy risks. |

**Table 12-2: Benefits and Challenges for cities form the Big Data Approach**

The way New York has approached it has been successful, and creating a Mayor's Office of Data Analytics, has led to creative thinking and the ability to draw from several different agencies for any problems that arise. Valuable insights have also been gained through the processing of huge volumes of data that the infrastructure has made possible.

Nevertheless, cities must worry about privacy issues, even for data that seems like it is anonymous. In New York, there have been a couple of examples of things like open data around taxi trips, where even though the individual records were not online, people were able to cross-reference those with other public data sets to find out things that might be considered more private information; for example, being able to look at a particular taxi and figure out what the earnings of that driver are based on the trips that they take and the starting and ending points. New York has seen success by working with organizations that have a strong social mission or particular set of issues that they focus on, such as homelessness or public housing. By working with them to specify the challenges and problems, the city has gained a stronger understanding than it otherwise would have through other means.

Another important example is Singapore, which created the Personal Data Protection Commission (PDPC) in 2013 to administer and enforce the Personal Data Protection Act (PDPA), with a mission to promote and enforce personal data protection. This was done to foster an environment of trust among businesses and consumers, contributing to a vibrant Singapore economy.

The PDPA generally follows a consent-based approach, and there are principles therein which support the concept of Big Data and the development of a Smart Nation. For one, the PDPA is non-prescriptive and centered largely on the notion of "reasonableness". Since the concept of "reasonableness" is not rigidly defined in the PDPA, it allows organizations a certain extent of flexibility in the use of personal data under their control.

PDPC is currently supporting national reviews of key data governance issues, and providing advice on personal data protection issues such as the types of personal data that should be handled, as well as how such data can be classified, and anonymized. With data protection issues being considered from the infrastructure level up, and ultimately ensuring that the Smart Nation initiatives are trusted by all stakeholders.

## 13 Interview with (ITU) International Telecommunication Union. Malcolm Johnson Deputy Secretary-General

### Q.1 What key technology and architecture do you believe are key requirements for the IoT in a Smart City?

The following diagram is a roadmap for the standardization of smart city which has been maintained by SG20. However, we think, in some sense, that it may also provide a high level view about required technologies and architectural areas of IoT (and supporting ICT) in a Smart City from the technical perspective.

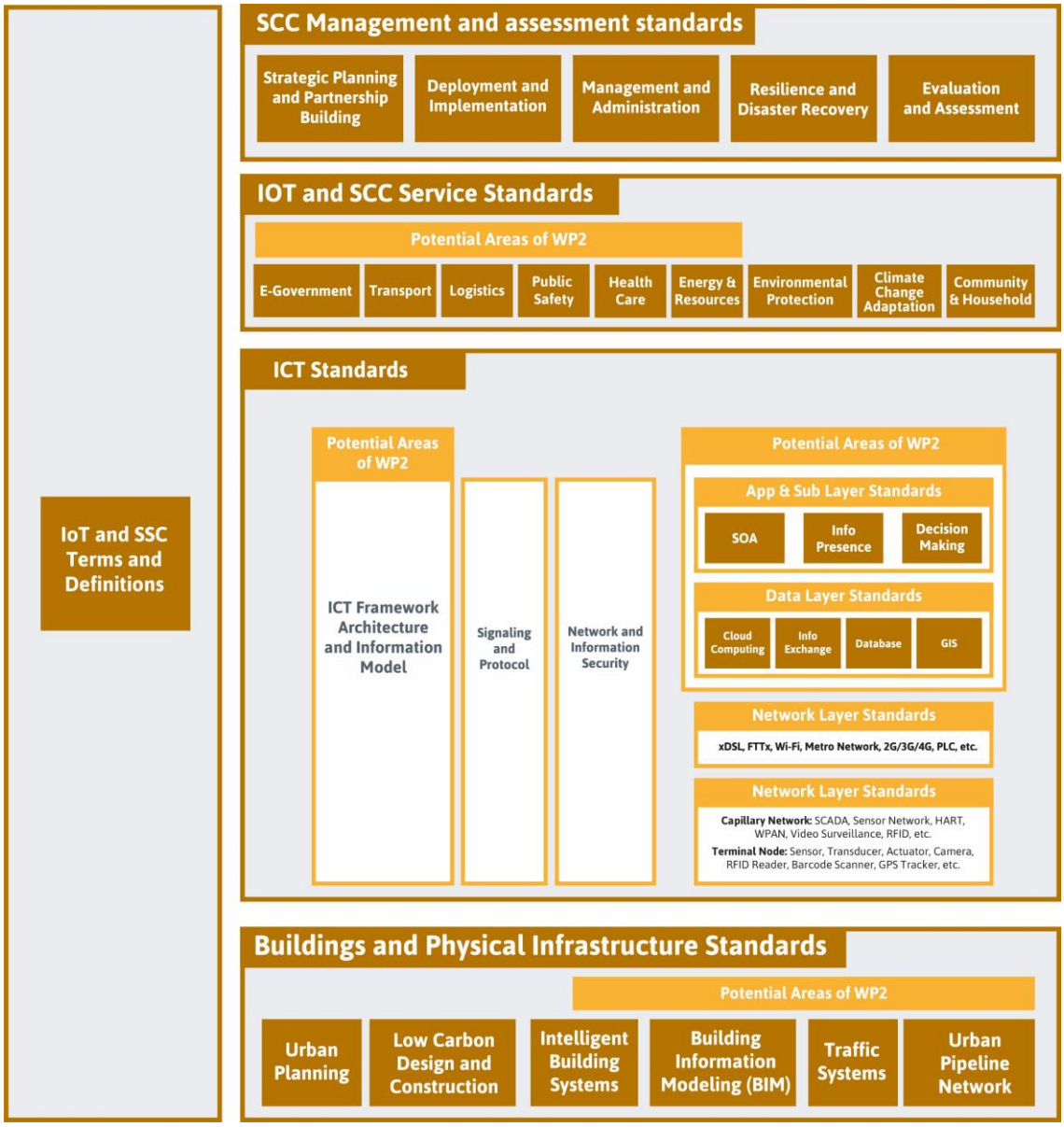



**Figure 43: IoT and SSC Terms & Definitions**

**Q.2 The Study 20 references the Aspect of IoT, what do you believe are the :-**

1) Requirements and capabilities of IoT applications and services?

Building on fundamental characteristics and high-level requirements of the IoT described in the Overview of the IoT and Common requirements for IoT applications has identified common requirements and capabilities of IoT applications and services as follows :

- Identification
- Identification-based connectivity
- Interoperability

- Autonomic networking
- Autonomic services provisioning
- Location-based capabilities
- Security
- Privacy protection
- Plug and play
- Manageability
- Compliance with laws and regulations
- Awareness of services
- Mobility support
- Scalability support
- Robustness against dynamic changes
- Self-organization (re-organization) and self-healing
- Energy efficient operation
- Common data format for collaborative data processing

A complementary basic reference from a "common requirements" perspective is Common requirements of the IoT.

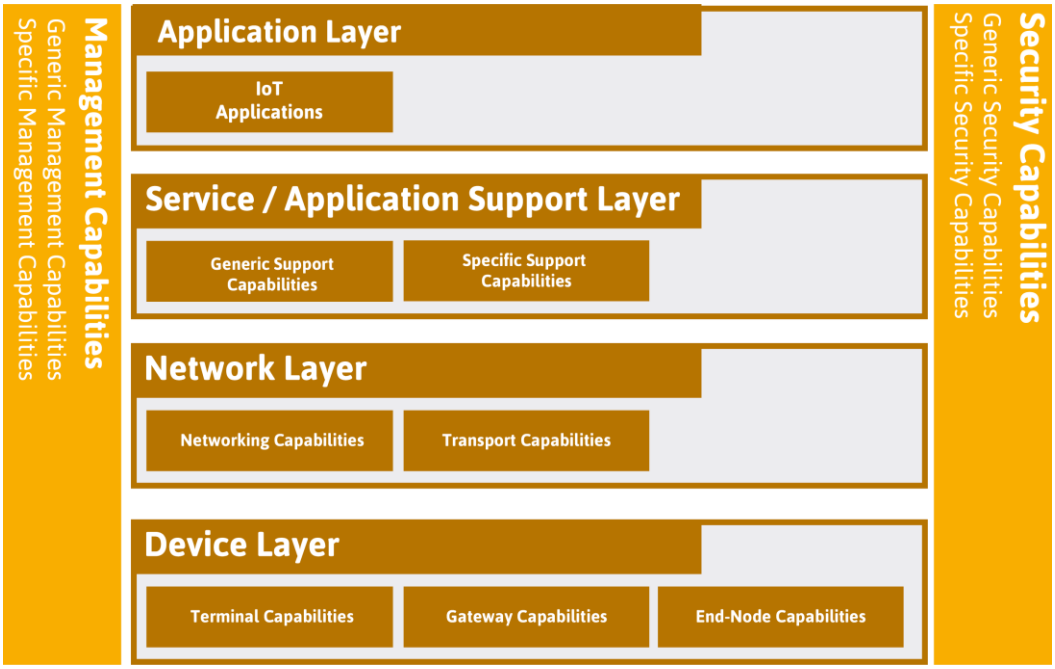
*nb – The term "common" wants to signify the independence of the requirements from specific application domain(s).*

The various (ongoing and published) studies on specific IoT applications and services aim to identify the specific requirements and capabilities of the IoT which are necessary to support those specific applications and services (see also points 3 and 4 below).

2) The Framework and Functional architectures of IoT to support networks and gateway?

**Requirements of the network for IoT** and **Common requirements and capabilities of a gateway for IoT applications** are basic references from network and gateway requirements perspective.

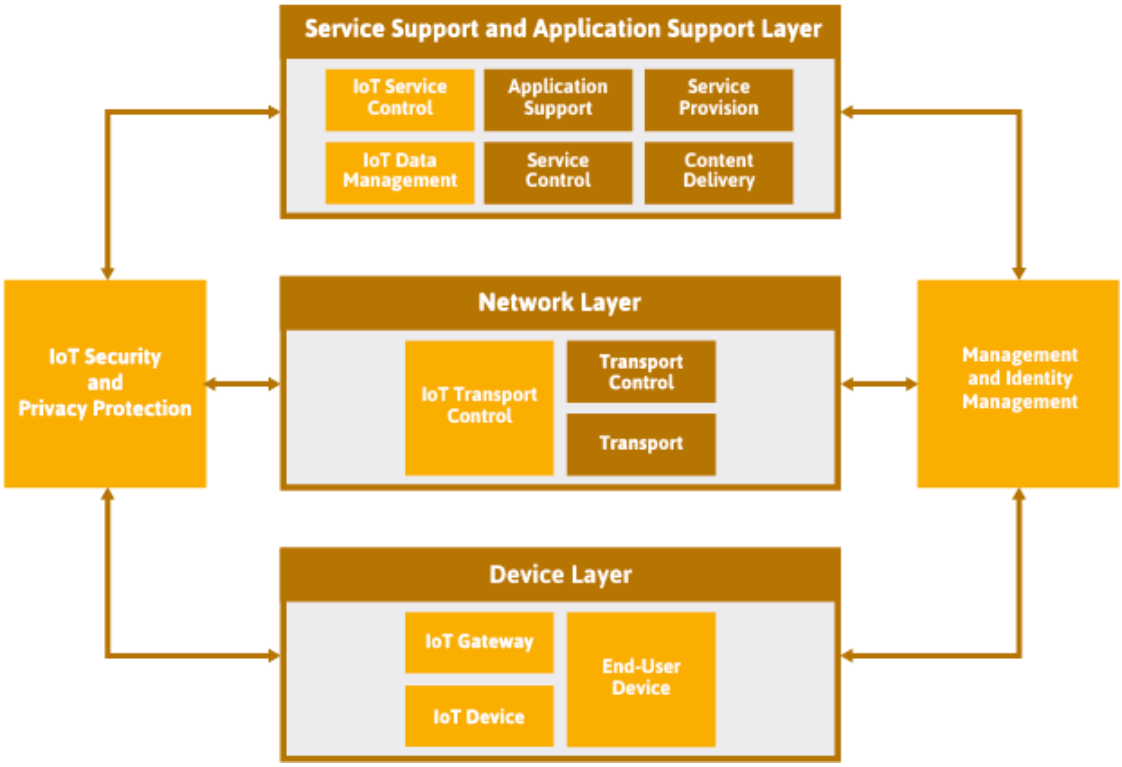
The basic ITU-T IoT Reference Model has been described in **Overview of the IoT**:




This model and the requirements expressed in **Common requirements of the IoT** are basis for the studies on framework and functional architectures. A basic achievement in this area is **Functional framework and capabilities of the IoT.**

Ongoing and published studies on functional architecture(s) of the IoT include studies on specific functional components (e.g. **Reference architecture for IoT network service capability exposure**). The specification of global functional architecture(s) of the IoT is in progress (this includes the adoption of relevant developments from other IoT related standards developments organizations (oneM2M)).

Only for information, the following picture illustrates the **Implementation view of the IoT functional** framework building over the **NGN functional architecture**




a) Specific IoT services that could cover transportation, e-health, safety services etc.?

In line with what mentioned in point 1, and illustrated in point 2 by the IoT reference model , the IoT aims to provide, in addition to generic support capabilities (which can be used by different IoT applications, e.g. data processing or data storage), specific support capabilities meeting the requirements of diversified IoT applications.

Examples of application-specific studies which have been completed or are in approval process include Capability framework for e-health monitoring services, Requirements of transportation safety service including use cases and service scenarios under AAP. Requirements and capabilities of Internet of Things for support of wearable devices and related service (under AAP).

### Q.3 What do you believe are the IoT based smart greenhouse, smart farming, smart manufacturing and Big Data issues?

ITU-T Study Group 20 is working on specific applications such as smart greenhouse, smart farming, smart manufacturing, as well as on enablers, such as those for the support of Big Data in IoT. The following is a list of ongoing/under approval studies in different application areas, as well as for the Big Data enablement:

| WORK ITEM | TITLE | SUMMARY |
|---|---|---|
| Y.fsn | Framework and Service scenarios for Smartwork | The Recommendation addresses a framework and service scenario for Smartwork in accordance with ICT (Information and Communications Technology) environments. |
| Y.ism-ssc | A Technical Framework of Integrated Sensing & Management for Smart Sustainable Cities | This draft Recommendation specifies a technical framework of ISMS for SSC. It clarifies the background, goal, significance, and intended effects of ISMS for SSC, proposes a technical framework, and lists the key technologies, components, information models, management interface and service operations used in ISMS. The use cases are also provided in an informative appendix. |
| Y.4116 (ex. Y.TPS-req) | Requirements of transportation safety service including use cases and service scenarios | Accidents and disasters caused by the transportation means affect much lives and properties. The transportation safety can be influenced by the fault of transportation means (i.e., cars, trains, ships, etc.), environmental status (i.e., wind, snow, freezing status, etc.), abnormal status of transportation infrastructure (i.e., bridge, tunnel, road, etc.) and some other human errors. The transportation safety services based on the IoT technologies can reduce the occurrence of accidents and disasters and save the lives and loss of properties in case of disaster. This Recommendation describes requirements for providing transportation safety services. The use cases and related service scenarios which are used to extract requirements for various IoT services and applications are also described in this Recommendation. |
| Y.AERS-reqts | Requirements and capability framework for IoT-based automotive emergency response system | This Recommendation is going to identify requirements of IoT-based automotive emergency response system (AERS) for aftermarket devices and to provide a capability framework of the AERS for aftermarket devices. Current standards deal only with OEM pre-installed system based emergency call system, targeting newly manufactured automobiles, however, there is no on-going standardization on aftermarket-device-based emergency response system for the cars currently on the road. Assuming that 5% of the automobiles on the road are replaced with new ones equipped with emergency call system every year, it will take more than 20 years for all the vehicles on the road to be equipped with emergency call system. |
| Y.IoT-ITS-framework | Framework of Cooperative Intelligent Transport Systems based on the Internet of Things | Cooperative ITS based on the Internet of Things are advanced systems which, without embodying intelligence as such, aim to provide innovative individual, personalized services relating to different modes of transport and traffic management, to enable users to be better informed and to make safer, more coordinated, and "smarter" use of transport networks. Road operators, infrastructure, individual vehicles, their individual drivers and other road individual users cooperate to deliver the most efficient, safe, secure and comfortable journey. The vehicle-vehicle and vehicle-infrastructure co-operative systems contribute to these objectives beyond the improvements achievable with a stand-alone system. |

| | | |
|---|---|---|
| Y.IoT-Retail-Reqts | Requirements and reference model of IoT applications for smart retail stores | Employing IoT technologies enables smarter retail stores. For example, IoT technologies will enable safe and efficient retail-store management system for non-stop operation (24 hours / 365 days). In this system, some information of various kinds of equipment in the stores is collected and monitored in real time at an application-server side. This enables early detection of equipment failure or accurate prediction of equipment trouble. In order that retail-store operators or store-equipment vendors can effectively employ the IoT technologies, it will be very helpful to provide them appropriate guidelines or recommendations of IoT applications for smart retail stores. |
| Y.IoT-UAS-Reqts | Use cases, requirements and capabilities of unmanned aircraft systems for Internet of Things | IoT is characterized by massive devices and high volume of small data. UASs can act as moving devices, and can act as base stations, relay and may act as data collectors to provide seamless coverage and reliable connectivity. To better support diverse applications, this proposal specifies use cases of UASs acting as a key part of IoT as wireless communication platform. The requirements and capabilities are also specified to adjust different use cases (UAS-aided ubiquitous coverage, UAS-aided relay, UAS-aided information dissemination and data collection). |
| Y.SEM | Requirements and capability framework of Smart Environmental Monitoring | This Recommendation provides the requirements and capability framework of Smart Environmental Monitoring. The provided requirements and capabilities framework are intended to be generally applicable in environmental monitoring. |

| | | |
|---|---|---|
| Y.SmartMan-IIoT-overview | Overview of Smart Manufacturing in the context of Industrial Internet of Things | Considering the global initiatives of Smart manufacturing and Industrial Internet of things, and close relationship of related technologies and trends, this Recommendation provides an overview of the Smart Manufacturing in the context of the Industrial Internet of Things. For this, this Recommendation presents key concepts and views, objectives of Smart Manufacturing in the context of the Industrial Internet of Things, identifies the fundamental characteristics, gives the high-level reference models, and business models as well as use cases. |
| Y.smartport | Requirements of smart management of supply services in smart port | This Recommendation provides requirements for the application and management of basic services (water supply, electricity and other accessories services) to Port facilities within Smart Port context. |
| Y.SRC | Requirements for deployment of smart services in Rural Communities | This Recommendation aims to establish basic conditions of operation of services (such as e-government, health, education, etc.) and contribute to the development of enterprises and create conditions for making smart communities attractive to the population. This Recommendation will contribute, inter alia, to boost agricultural and livestock rural development, inter-municipal cooperation, preservation of the natural environment, social and cultural connectivity, tourist information including sustainable tourism for smart rural communities. This Recommendation will also contribute to bridge the digital gap to enhance a better quality of life for citizens in smart rural communities. |

| | | |
|---|---|---|
| Y.disaster-notification | Framework of the disaster notification of the population in Smart Cities and Communities | This Recommendation introduces disaster notification, which should facilitate effective and efficient solutions. This Recommendation describes concepts, features and technical aspects of disaster notifications in disaster and/or emergency situations. This Recommendation specifies requirements, functional reference model along with use cases. |

| | | |
|---|---|---|
| Y.ISG-fr | Framework of IoT-based Smart Greenhouse | Smart greenhouse is an IoT-based approach toward food production. The goal of smart greenhouse is to provide and maintain optimal conditions for growing crops in greenhouse environment; the optimal growth conditions can be automatically adjusted with help of a number of sensors and actuators. Most popular controllable variables for optimal growth conditions are temperature (air, nutrient solution, root-zone), humidity, carbon dioxide (CO2), light (intensity, spectrum, interval), nutrient concentration (PPM, EC) and nutrient pH (acidity). |
| Y.psfs | Functional model for production service of Smart Farming | The standard of the greenhouse control system defines the components in applying IT technologies to a greenhouse and specifies the requirements and the architecture for the technological issues. The system collects information for the growth management of corps and can control the facilities promoting the optimal growth environments in greenhouse. This system includes the growth environment management service, the growth environment control service, and etc. |
| Y.SC-Residential | Requirements of Smart Residential Communities | Smart residential communities based on ICT (information and communication technology) provide all kinds of e-services and smart services for government, enterprises and individuals related to the residential community. This recommendation describes requirements of Smart Residential Communities management and services, provides a reference architecture and service capabilities of Smart Residential Communities. |
| Y.smart-evacuation | Framework of Smart Evacuation during emergencies in Smart Cities and Communities | This Recommendation introduces smart evacuation, which should facilitate effective and efficient solutions. This Recommendation describes concepts, features and technical characteristics of smart evacuation in disaster and/or emergency situations. This Recommendation specifies high-level requirements, functional reference model along with use cases. |

| | | |
|---|---|---|
| Y.SPL | Requirements and Functional Architecture for Smart Parking Lots in Smart City | This Recommendation specifies requirements and functional architecture for Smart Parking Lots (SPL) to provide the rich parking services for people to improve the convenience of city life and support the standardization for the vendors to produce the better products. SPL provides various intelligent parking services for on-street and off-street parking lots to improve the convenience of parking, including vehicle automatic access, parking guidance, self-service payment, parking space reservation and vehicle reverse search. SPL is composed by off-street and on-street smart parking lots and smart parking networking platform with external interfaces for related external systems. |

| | | |
|---|---|---|
| Y.SSL | Requirements and Reference Framework for Smart Street Light | As an important part of smart cityrk for Smart Street Light and off-street parking lots to improve the convenience of parking, including vehicle automatic access, parking guidance, self-service paymeThis draft Recommendation specifies the requirements, framework and related core functions of Smart Street Light. Related use cases are provided in the appendix. |
| Y.STD | Functional Architecture for Management to Smart Tourist Destinations | As an application of the concept of Smart City, a Smart Tourist Destination should be based on innovation, technology, sustainability and accessibility; a model capable of ensuring the tourism sustainability today and in the future. The objective is to describe the functional architecture for manage to smart tourist destination, and specifically integrate in a platform a dataset of indicators and metrics from many sources that allows to monitor the tourist destination and to manage the public services in a more efficient way. Moreover, the dataset will be the basis to strength the relationships between the public and private agents which forms the tourist destination, establishing pathways between them and the tourists and the resident citizens. A standardized reference model improves understanding from both the receptor country and the emissary country, making possible to improve the competitiveness of the tourism sector whilst enhancing the quality of tourists experience throughout the life cycle of their interaction with the destination. |

| | | |
|---|---|---|
| Y.STIS-fdm | Function description and metadata of Spatio-temporal Information Service for SSC | People, things and events as the basic elements of a city are becoming more and more dependent on information service, especially information related to space and time, which is also called spatio-temporal information service (S-TIS). Though relevant service have already emerged and provided in small scale, the lack of standard could limit their serving ability to meet the rising demand across the global. Therefore, a standard is needed to specify what spatio-temporal information services, including the function description and metadata of spatio-temporal information service, should be provided for SSC. This recommendation specifies function description and metadata of Spatio-temporal Information Service for SSC. |
| Y.4114 | Specific requirements and capabilities of the Internet of things for big data | Recommendation ITU-T Y.4114 specifies requirements and capabilities of the Internet of things (IoT) for big data. This Recommendation complements the developments on common requirements of the IoT described in Recommendation ITU-T Y.4100/Y.2066 and the functional framework and capabilities of the IoT described in Recommendation ITU-T Y.2068 in terms of the specific requirements and capabilities that the IoT is expected to support in order to address the challenges related to big data. This Recommendation also constitutes a basis for further standardization work such as functional entities, application programming interfaces (APIs) and protocols concerning big data in the IoT. |

**Q.4 What are the key Security, Trust and Privacy protection issues relating to IoT?**

The era of IoT has changed our living styles. The society and digital economy are witnessing an unimaginable level of value from the introduction of connectivity, collective action, intelligence, and pervasive computing paradigms being brought by IoT and its applications including smart cities and communities. IoT is bringing significant benefit to the home, office, plant, and factory. Wearables, and augmented reality are enhancing the lifestyle of the people and are promising new paradigms of user experience.

Although the IoT provides huge benefits, it is prone to various security threats in our daily life. The majority of the security threats are related to leakage of information and loss of services. In IoT, the security threats straightforwardly are affecting the physical security risk. The IoT consists of different devices and platform with different credentials, where every system needs the security requirement depending upon its characteristics. The privacy of a user is also most important part because a lot of personal information is being shared among various types.

While traditional security constructs like confidentiality, availability, authentication, authorization, non-repudiation, conditional access, fidelity or integrity, still are the main countermeasures for most associated ICT risks, there is a need however to address other dimensions that go beyond securing data transmission, reception, storage, or processing.

Too many IoT systems are being designed for comfort and ease of use, while long term security and security by design aspects, in addition to safety remain far from being implemented on the ground. There is usually no process for the continuous updates of the device's firmware to apply security patches, and usually no means to notify the user the device is up to date, or whether the device needs a critical security update to mitigate prominent emerging risks.

Many IoT systems have unsecured remote access, with no policies, norms, or regulations harmonizing data use, storage, and/or processing. By default, many collect large amounts of Personally Identifiable Information (PII) which can be used to identify the identity of the end user, and this information is usually shared or traded through analytics, big data, and IoT platforms. The right for the user to be forgotten may not be fully implemented, and there is no easy way for the user to file a complaint or liaise with a company representative for any issues related to security and privacy.

Taking into consideration the importance of data for the development of IoT and especially in the context of smart cities and communities, an ITU-T **Focus Group on Data Processing and Management to support IoT and Smart Cities & Communities** (FG-DPM) was established. A key priority of this Focus Group is to propose mechanisms, frameworks and guidelines for supporting the security, privacy and interoperability of datasets and data-management systems within the IoT and smart city domain. The first meeting of the FG-DPM was held from 17 to 19 July 2017 in Geneva, Switzerland. The work of the FG-DPM is being carried out through the following Working Groups:

- WG1 - Use Cases, Requirements and Applications/Services;
- WG2 - DPM Framework, Architectures and Core Components;
- WG3 - Data sharing, Interoperability and Blockchain;

- WG4 - Security, Privacy and Trust including Governance; and
- WG5 - Data Economy, commercialization and monetization.

The application data of IoT could be industrial, enterprise, consumer or personal. This application data should be secured and must remain confidential against theft and tampering. For example, the IoT applications may store the results of a patient's health or shopping store. The IoT improve the communication between devices but still, there are issues related to the scalability, availability and response time. Security is a concern where the data is securely transmitted over the internet.

Among different security challenges, some of the most important challenges relevant to IoT include:

1) Data Privacy: For example, some manufacturers of smart TVs collect data about their customers to analyze their viewing habits so the data collected by the smart TVs may have a challenge for data privacy during transmission.

2) Data Security: Data security is also a great challenge. While transmitting data seamlessly, it is important to hide from observing devices on the internet.

3) Insurance Concerns: The insurance companies installing IoT devices on vehicles collect data about health and driving status in order to take decisions about insurance.

4) Technical Concerns: Due to the increased usage of IoT devices, the traffic generated by these devices is also increasing. Hence there is a need to increase network capacity, therefore, it is also a challenge to store the huge amount of data for analysis and further final storage.

5) Security Attacks and System Vulnerabilities: taking into consideration system security, application security, and network security.

   a) System Security: System security mainly focuses on overall IoT system to identify different security challenges, to design different security frameworks and to provide proper security guidelines in order to maintain the security of a network.

   b) Application security: Application Security works for IoT application to handle security issues according to scenario requirements.

   c) Network security: Network security deals with securing the IoT communication network for communication of different IoT devices.

6) Lack of Common Standard: Since there are many standards for IoT devices and IoT manufacturing industries. Therefore, it is a big challenge to distinguish between permitted and non-permitted devices connected to the internet.

Therefore, it is important that security and privacy concerns are taken into account throughout the design process of products and systems to be used in IoT implementations commonly known as privacy by design and security by design, which emphasize that protections be built into information technologies, business practices, systems, processes, physical design, and networked infrastructure.

The satisfaction of security and privacy requirements plays a fundamental role in the IoT environment and smart cities. Such requirements include data confidentiality and authentication, access control within the IoT network, availability, data integrity, privacy and trust among users and things, and non-repudiation.

For this reason, security, privacy and trust provisioning for IoT is one of the outstanding standardization issues of the ITU-T SG20.

A Key aspect in realizing secured and trustworthy IoT systems is the aspect of identification. The connectivity of IoT are usually employed at different layers. Connectivity from the sensors/actuators to the gateway and from the gateways (if they are present in the architecture) to the core network can be realized using a variety of technologies and infrastructures. Different levels of identification (for example device identifiers, process identifiers, gateway identifiers, connection identifiers, protocols identifiers, platform identifiers, application identifiers.) are needed to enforce security constructs like authentication and authorization. Otherwise, there is a huge risk of letting an unauthorized device to access the network, and compromise the whole system.

The identifiers should be immutable, and resistive to different types of attacks to ensure that no person or entity is able to forge the identifier, and fool the system into believing that the attacker's node is a legitimate node. Risks are aggravated when the things are associated with critical infrastructure of a smart city like transportation, medical facilities and power plants.

For example, IoT and its applications including smart cities and communities ( SC&C) has developed Recommendation Identifier service requirements for the interoperability of smart city applications

"Identifier service requirements for the interoperability of smart city applications". This Recommendation specifies a set of requirements for identifier services in smart city applications with a view to ensure that such systems are interoperable and secure. This set of requirements may additionally serve as guidelines for developing new identifier services for smart city. It will include security features for service integrity, data confidentiality. The Recommendation will define a full list of identifier service requirement, including security requirements, for the identifier service.

**Q.5 The Study 20 references the Aspect of Smart Cities and Communities (SC&C) ecosystems, applications, services and use case what do you believe are the :-**

The standards to focus on that will directly relate to SC&C in relation to:-

- Urban Planning
- Water
- Mobility
- Logistic
- Healthcare
- E-Government
- Education
- Transport
- Energy

The above standardization requirements have been addressed in the following two technical reports which had been developed by ITU-T Focus Group on Smart Sustainable Cities (FG-SSC):

- TR on "Standardization roadmap for smart sustainable cities"
- TR on "Standardization activities for smart sustainable cities"

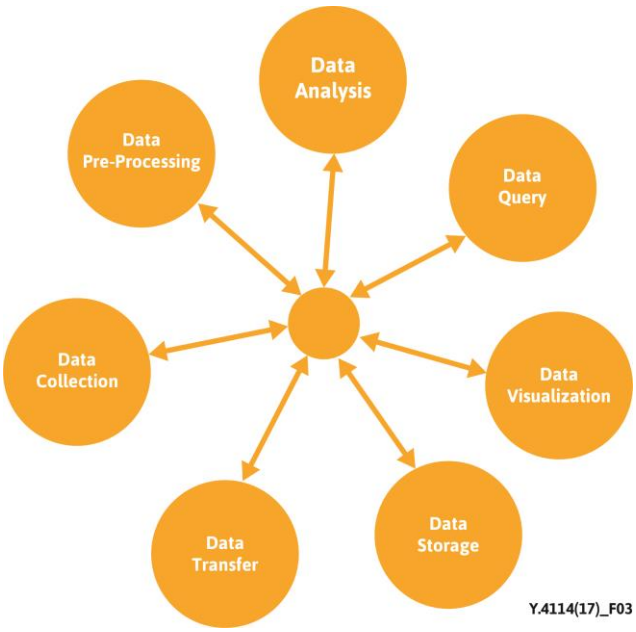
**Q.6 How important would you say is it that IoT devices and applications have open data platforms?**

Data analytics is a key revenue opportunity in the IoT market.

Analytics of data can allow organizations to drive revenue and/or address societal challenges by sharing, analyzing and interpreting data, for multiple purposes.

According to the specific business/social context, and the specific application and policy requirements, it is expected that open data platforms be supported in order to benefit of the intelligence that can extracted from the data of the IoT.

From a technical perspective, key operations on IoT data and related data flows of IoT devices and applications have been schematically illustrated in Specific requirements and capabilities of the Internet of things for big data as follows:




It is expected that open data platforms be specified addressing the different IoT data operations in the IoT, including data collection, data pre-processing, data analysis, data transfer, data storage, data query and data visualization.

**Q.7 The study references spatial-temporal modelling for SC&C which would result in significant data be gathered across a Smart City, what do you see as the key possibilities that could arise from this scenario?**

The Spatial-Temporal Information Services (S-TIS) for a smart city include Catalog Service for Spatio-temporal Information, Positioning Service, Navigation Service, Timing Service, Place Data Service, Analysis Service and Geospatial Knowledge Service.


**Spatio-temporal information service is important for people, things and events:**

- The spatio-temporal information service can be provided to people for their daily travel and lives, for example, telling them where they are, the shortest path from one place to another, how many supermarkets are around them within a certain distance.
- The spatio-temporal information service can be provided to things to position them and make them aware of their circumstances around which is especially fundamental and important in autonomous driving.
- The spatio-temporal information service can also be provided to events to assist in correct handling of them and scientific decision-making.

**Q.8 Which Cities have you seen that are leading the way in IoT in Smart Cities and what is that they are doing that stands out for you?**

In May 2016, the ITU and the UNECE launched the "United for Smart Sustainable Cities" (U4SSC) initiative in response to SDG11.
U4SSC is now a UN initiative coordinated by ITU and supported by CBD, ECLAC, FAO, UNECA, UNECE, UN-Women, UNEP, UNEP-FI, UNFCCC, UN-Habitat, UNIDO, WMO and WTO.

The U4SSC facilitates the development of public policies to encourage the use of ICTs to facilitate and ease the transition to SSC. Part of this advocacy emphasizes the potential of SSC in accelerating job creation by enabling new business opportunities for small and medium-sized enterprises (SMEs).

Within U4SSC, ITU has been working with over 50 cities that are committed to achieve SDG11 and are implementing ITU-T Recommendations as part of their city strategies.

Dubai was the world's first city to implement ITU's Key Performance Indicators for Smart Sustainable Cities. Singapore quickly followed suit, later followed by other 50 cities, including Manizales (Colombia), Buenos Aires, Pully, Valencia and Wuxi (China).

Dubai reported on the results of their experience in an ITU case study which charts the Smart Dubai journey from its initial planning stages through to the current status of related ICT applications, highlighting lessons learned along the way. The study offers an evaluation of Dubai's progress in meeting its smart-city objectives, evaluations undertaken using ITU's KPIs. The results of the evaluation is assisting Dubai in refining its smart-city strategy.

Smart Dubai is anchored in the vision of His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice-President and Prime Minister of the UAE and Ruler of Dubai, to make Dubai the happiest city on earth. Collaborating with private sector, UN agencies such as ITU and government partners, Smart Dubai is facilitating Dubai's citywide smart transformation, to empower, deliver and promote an efficient, seamless, safe and impactful city experience for residents and visitors.
The United 4 Smart Sustainable Cities (U4SSC) developed a series of flipbooks that contains several examples of cities that are taking action to become smarter and more sustainable:

- Flipbook on 'Connecting cities and communities with the SDGs';
- Flipbook on 'Enhancing innovation and participation in smart sustainable cities'; and
- Flipbook on 'Implementing SDG11 by connecting sustainability policies and urban planning practices through ICTs'.


In view of the growing U4SSC network, we welcome all experts who are interested in contributing to this dynamic and far-reaching initiative.

The U4SSC is currently working on the following deliverables:

- Guidelines on tools and mechanisms to finance SSC projects;
- Guidelines on strategies for circular cities;
- City science application framework;
- Guiding principles for artificial intelligence in cities;
- Blockchain 4 cities and
- Toolkit for Smart Sustainable Cities.

## 14 Conclusions and Next Steps

Leveraging on the valuable contributions provided from the different stakeholders to this paper, the following conclusions and key takeaways could be derived:

**Smart City Definition, Understanding Challenges and Opportunities.**

Having a common understanding of the definition of Smart / Connected City is a key starting point for a wider discussion on the challenges and opportunities cities are having – "Smart city involves an ecosystem platform of multi-stakeholders and utilizes integrated information and communication technology systems, ICT, and data analytics, to transform its culture, its structure, its operations, and economic development, and citizens' engagement, to manage complexity and dynamically improve and enhance quality of life"

Greater understanding of the issues and with this we are starting to see emerging trends. More integrated approaches to city issues that have seen a breakdown in some of the silo approaches to energy, housing, transport and health for example. Supporting the appearance of city platforms with more cohesive

strategies and management of big data and IoT. Expanding the partner ecosystems to enable the delivery of the connected city vision. Uniting the gap between connected city programmes and city priorities

Smart Cities are more than just the implementation of various technologies. “Smart” does not only refer to technology or sensors. Smart is a concept and new kind of culture for how cities and its agencies can work more effectively both internally, with partner agencies and organizations and, of course, with their citizens. Smart is a way of transforming from the way things have always been done. Smart Cities are not a destination to arrive at, but a new process for managing how cities and agencies work;

Technology Benefits. It is essential for cities to know and visualize the benefits from the different technologies available today and in the near future to pursue a more effective connected city and efficient collaboration with the other stakeholders.

The proliferation of network technologies in the Unlicensed, Licensed, Broadband, Wireless, Internet of Things (IoT), Industry Collaboration Forums, among others, are all key elements that cities need to embrace to foster their connectivity plans and maximize their resources;

Services Deliver will need an in-depth understanding of the implementation models of various use cases (verticals), in areas of big data, network interoperability, public-private partnerships and others are critical factors for the success of the cities service delivery.

Identifying best practices, gaps, share learnings, research, developing trials and tests, are all key elements for cities to develop in a more effective and efficient way their connectivity plans and the vision of a Smarter City;

As next steps the CCAB and the WBA intend to continue the development of this Connected City Blueprint, both in terms of additional content as well making it available to the industry in different channels, including an online eBook version. This is an Industry collaborative effort and the CCAB would like to invite the different stakeholders to get involved in this initiative. The Connected City Blueprint can be considered a living document and through 2018 the CCAB will be releasing updated versions.

**HAVE A VOICE IN THE FUTURE OF CONNECTED CITIES**

**Cities and associations are invited to contact WBA at:**

**contactus@wballiance.com**

**For more information about the CCAB please visit:**

**wballiance.com/ccab**