

Machina Research

Strategy Report

The Smart City Playbook: smart, safe, sustainable

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1 Executive Summary

1.1 About this report

This report has been sponsored by Nokia with the aim of illustrating the experience and learnings from a number of cities at different stages on the smart city journey. As a specialist IoT analyst house, Machina Research has naturally chosen to focus the research for this report on those aspects of smart cities that are most closely aligned to the IoT.

We have selected a group of cities of varying sizes, geographies and levels of progress in terms of 'smartness' so as to investigate the key parameters and lessons involved in becoming smart.

1.2 Key messages

The report aims to provide smart city stakeholders with relevant insights on strategies, solutions, and pitfalls to be avoided, in the process of becoming smarter cities.

Conclusions and Recommendations

- **Data matters. So does sharing it, on the right terms. Cities need to put in place rules to make sure that they get the most benefit from data assets.**
- **Coordination of smart initiatives across different departments doesn't just happen. Getting it right requires forethought and leadership.**
- **Ultimately it's the citizens that are paying for the smart city. Vendors and city authorities need to engage them to make the benefits visible.**
- **Procurement departments need to be better educated. This will enable them to evaluate bids more effectively and allow for new kinds of relationship.**
- **Smart city solutions can help to revive declining cities or districts, and this can build support and mobilize resources for projects.**
- **The best project structures enable cities to work closely with ICT vendors without getting locked into proprietary ecosystems.**

The 22 cities covered in the study were:

• Auckland	• Cleveland	• Pune
• Bangkok	• Delhi	• San Francisco
• Barcelona	• Dubai	• Sao Paulo
• Berlin	• Jeddah	• Shanghai
• Bogota	• Mexico City	• Singapore
• Bristol	• New York City	• Tokyo
• Cape Town	• Paris	• Vienna
		• Wuxi

A mature smart city enables individual citizens, businesses, NGOs, and the municipality to both contribute and extract data, and to create and make use of applications (including automated controls) based on that data.

The drivers for cities to become smart include:

- Demographic pressures
- Environmental pressures
- Fragility - vulnerability to natural disasters and/or inability of the city infrastructure's ability to cope with rapid social and economic change.
- Financial pressures and a need to 'do more with less'
- Economic pressures - increased competition¹ between cities within and across regions

1.3 Three routes to becoming 'smart'

These pressures are of course different for every city, and the way they respond to these pressures manifests itself in different ways. We have identified three routes towards a mature smart city:

- An 'anchor' route, in which the city adds working applications in series. Such cities have sought to deploy one or more stand-alone applications, ensure that these are working properly, and then think about how they might be extended and/or integrated with each other. These cities have a clear and pressing need for the 'anchor' application, to which others are then added as priorities dictate.
- A 'platform' route, in which the city focuses on deploying infrastructure first so that a number of applications can be delivered later. Platform cities have tried to get the network infrastructure - and/or a common platform for different applications - in place first, and then to sort out how applications can be added or existing services integrated with it.
- A 'beta city' route, in which the city continues to experiment with multiple applications without a finalised plan for how to bring these pilots to full operational deployment. Beta cities accept that the currently available technologies and business models can only be provisional and prioritise hands-on experience over short-term or medium-term tangible benefits.

We do not believe that one of these three routes is the 'right' answer. Each has something to recommend it, and which one fits best will depend on the city's resources, issues, and priorities. A 'beta' approach may deliver more visible 'easy wins' quickly. An 'anchor' approach might be absolutely determined by a single issue, such as preparations for earthquakes, which dwarfs all others.

Few cities are pursuing an absolutely pure form of one of these routes. Most have something of more than one route; either they are hedging their bets, or are in the process of shifting from one route to another. Several are at such an early stage that they have not yet settled down into one route or another.

1.4 New business models and technologies are key enablers

The study also identifies important developments in technology and business models which have helped to enable cities to become smarter:

- More and better connectivity options, and a renewed appreciation of the role of the public sector in driving, supporting and financing communications infrastructure.
- New tools and paradigms for ingesting, managing, storing and analyzing data, including cloud architectures and machine learning.
- The increasing influence of the open data models in the public sector.
- The Living Labs paradigm for research and development.
- The advent of smartphones as a near-ubiquitous sensing and user interface device.
- Platform-as-a-Service (PaaS) and Software-as-a-service (SaaS) business models.
- The rise of open source software and the growing popularity of open APIs as a counter to proprietary lock-in.
- The rise of new financing and funding paradigms, especially Public-Private Partnerships (PPP) and vendor financing.

1.5 Data is central to the smart city

The centrality of data is a common theme across smart cities. Data can be provided either via open data portals or through paid-for data marketplaces; in both cases the expectation is that third parties may be better able to exploit the data than the city could itself.

This data can come from many sources, including:

- the operational procedures of the city's agencies (such as demographic and household data, school rolls or highway repairs);
- crowdsourced data actively contributed by citizens via smartphone applications, web pages and messages, or passively contributed by automated smartphone apps which make use of the devices' embedded sensors;
- from the IoT, those physical devices, vehicles, buildings, infrastructure and other items which have been embedded with electronics, software, sensors, actuators, and network connectivity so as to enable these objects to collect and exchange data.

For this report we have grouped city-oriented IoT applications into three broad categories:

- Smart Living: IoT applications aimed at improving the quality of life for citizens, and support economic development, thereby making cities more attractive places to live.
- Smart Safety: IoT applications aimed at helping to prevent, or minimize the risks and impact of, adverse events including crime, accidents, environmental pollution and natural disasters.
- Smart Sustainability: IoT applications intended to reduce the environmental impact (especially energy consumption and carbon emissions) of the city, its businesses and its citizens.

We have given each of the 22 cities a score for each of these categories to reflect their progress and focus.

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3 Scope

This report has been sponsored by Nokia with the aim of illustrating the experience and learnings from a number of cities at different stages on the smart city journey. We have selected a group of cities of varying sizes, geographies and levels of progress in terms of 'smartness' so as to investigate the key parameters and lessons involved in becoming smart.

The report aims to provide smart city stakeholders with relevant insights on strategies, solutions and pitfalls to be avoided in the process of becoming smarter cities.

The report is based on a combination of desk research and interviews with the cities profiled in Section 5.

4 Smart cities in view

4.1 Why cities need to become smart

The drivers for cities to become smart have been widely discussed, not least in our reports. These include:

- Demographic pressures, including the rapid growth of many cities, especially in emerging markets, as a result of population growth and inward migration – but also the decline of former industrial cities, especially in developed country heavy industry regions, and the changing age structure (“ageing population”)² in many developed country cities. This issue looms large in many of China’s cities.
- Environmental pressures, caused to some degree by population growth and increasing ‘motorization’³ in developing country cities and the inability of their infrastructure to keep pace with this growth, but also by the increased awareness of human-created climate change and the consequent vulnerability of cities to changing weather patterns and extreme weather events.⁴ Air quality is an increasingly important aspect of urban environments, a burden on healthcare systems and a political issue for city authorities⁵.
- Fragility, in terms of vulnerability to natural disasters but also inability of the city infrastructure’s ability to cope with rapid social and economic change.⁶ Natural disasters focus the minds of city managers, helps them set priorities and bypasses conventional evaluation. Where there has been a history of such disasters cities are much more ready to deploy solutions which will help them manage future events. Those cities with memories of disasters and a focus on resilience are inclined to take a longer-term perspective; Mexico City has a development plan that runs to 2040.
- Financial pressures, exacerbated by the financial crisis of 2007-8, has meant that many cities have suffered big cuts to their budgets. Measures taken by central governments to manage their own levels of debt have exacerbated this and further diminished the funds available to cities.⁷ This has led to a need to ‘do more with less’, but also to openness to innovative business models and financial arrangements including private public partnerships for the construction and operation of infrastructure.
- Economic pressures, as a result of increased competition⁸ between cities within and across regions to attract footloose globalized capital and affluent citizens, with multiple city rankings and ‘quality of life’ indices informing their choices. There is a strong perception that cities with good connectivity⁹ and a positive attitude to technology will be more successful in attracting

² <http://www.un.org/esa/population/publications/worldageing19502050/>

³ <https://www.nap.edu/read/10491/chapter/4#15>

⁴ See for example <http://siteresources.worldbank.org/INTUWM/Resources/340232-1205330656272/4768406-1291309208465/PartII.pdf>

⁵ http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/

⁶ <https://www.foreignaffairs.com/articles/africa/2015-01-15/fixing-fragile-cities>

⁷ See “Austerity in the city: economic crisis and urban service decline?” (Cambridge Jnl Regions, Econ and Society Volume 7, Issue 1 Pp. 3-15). <http://cjres.oxfordjournals.org/content/7/1/3.abstract>

⁸ For a contrasting view see ‘Competition and Cooperation Between Cities in Globalization’ <http://www.lboro.ac.uk/gawc/rb/rb351.html>

⁹ <http://nextcenturycities.org/>

businesses, especially start-ups, which may be an important element in the regional development¹⁰.

There are also important developments in technology and business models which have helped to enable cities to become smarter:

- More and better connectivity options, including new network technologies including high speed fixed and mobile broadband, public access WiFi, as well as low power wide area (LPWA) technologies which offer low-touch, cheaper devices and better link margins for connecting objects. The advent of variants of LTE more suited to IoT implementations in terms of cost and performance characteristics is also very important.
- A renewed appreciation of the role of the public sector in driving, supporting and financing communications infrastructure. Years of reliance on a competitive marketplace and access-based competition have given way to national broadband plans¹¹ in many countries; these often intersect with an overall digital strategy, and with both central and local government's plans for urban regeneration. Japan, China and India all have such plans in place; in the case of the latter two countries the impact on smart city implementations has been considerable.
- New tools and paradigms for ingesting, managing, storing and analyzing data, including cloud architectures and machine learning
- The increasing influence of the open data models in the public sector, i.e. the view that some data should be freely available, in standardized formats, to everyone to use and republish, without constraint from copyright, patents or other mechanisms of control
- The Living Labs paradigm for research and development, which has gained considerable traction in the smart cities domain¹². A key element of Living Labs is the engagement of users as 'co-creators' rather than merely research subjects of the evaluation process; this inevitably involves new research methodologies including crowd-sourcing and mass collaboration.
- The advent of smartphones as a near-ubiquitous sensing and user interface device in the hands of citizens
- Platform-as-a-Service (PaaS) and Software-as-a-service (SaaS) business models, together with the rise of open source software and the growing popularity of open APIs as a counter to proprietary lock-in
- The rise of new financing and funding paradigms, especially Public-Private Partnerships (PPP) and vendor financing. The former has sometimes been proposed as a mechanism for managing public finances without incurring debt, but it may be particularly appropriate where an investment decision has a long payback period and where there is an imbalance of expertise between the buyer (in this case the city) and the provider (a technology or network service provider).

4.2 What is a smart city?

There is no single agreed definition of a smart city. We like the October 2015 definition offered by the ITU-T Focus Group on Smart Sustainable Cities:

¹⁰ <http://www.nber.org/papers/w17793>

¹¹ <http://www2.deloitte.com/uk/en/pages/technology-media-and-telecommunications/articles/national-broadband-plans.html>

¹² See for example <http://www.openlivinglabs.eu/> and <http://cities.media.mit.edu/>

“A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects.”¹³

But the same Focus Group reported that it had found more than 100 different definitions, and others have reported as many as 200.

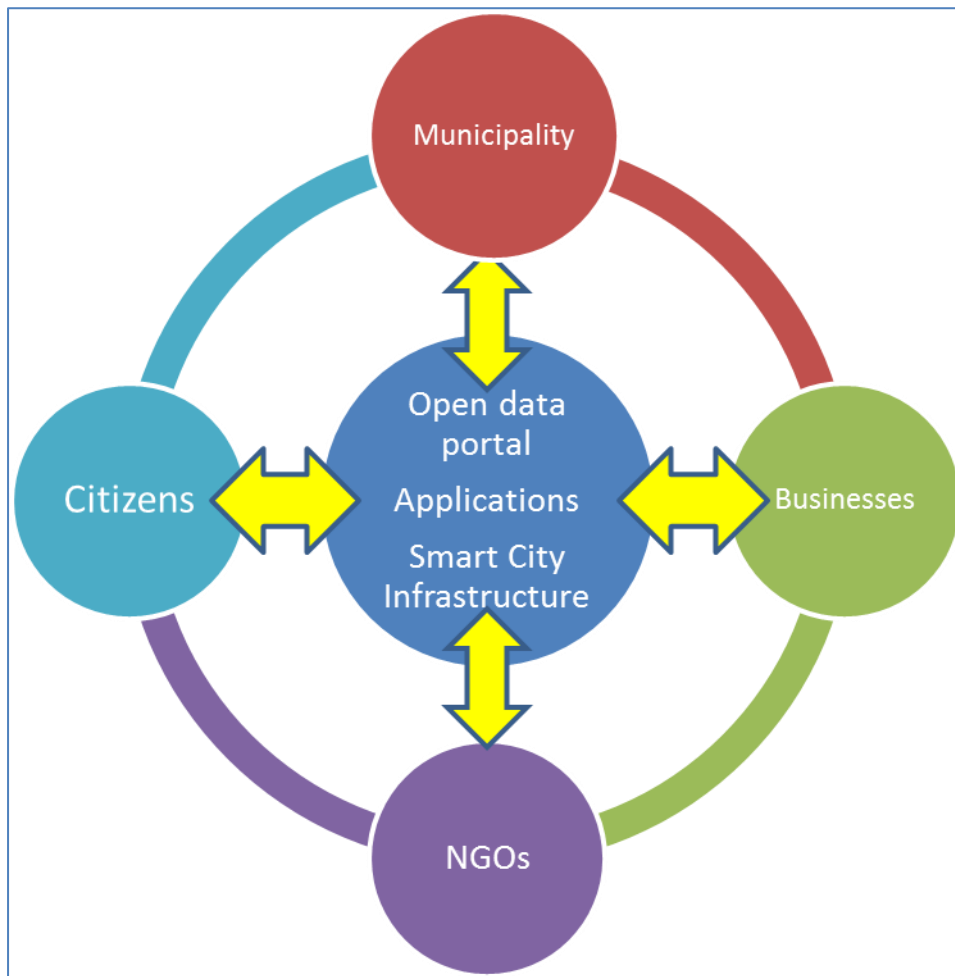
This is not just a semantic squabble. There are different ways of being a smart city. Some cities have focused on improving the operational efficiency of their own municipal services such as street lighting, waste collection and parking services. Others have given priority to engaging with citizens, including ‘citizen’ sensing via smartphone apps and the web, participatory planning and engagement with the city’s departments. While many cities argue that smartness is about making the best use of data, others are keen to provide cultural or technology-based services (such as free public WiFi) so as to become more attractive places to live and work.

Cities vary according to how far along their smart city journey they have travelled, with some at a very early planning stage, others in pilots and trials, and a few with fully operational deployments of applications. It is tempting to segment cities in to early adopters, fast and slow followers, and late developers.

A mature smart city would enable individual citizens, businesses, NGOs and the municipality itself (including its business processes and its IT systems, and sensors attached to its physical assets) to both contribute and extract data, and to create and make use of applications (including automated controls) based on that data. We illustrate this, somewhat simplistically, in Figure 1.

¹³ <http://www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx>

Figure 1 A conceptual model of a mature smart city



4.3 The road map towards the smart city

However, not only is there no consensus on the destination of the smart city journey, there are also wide differences on the route and the mode of travel.

- Some cities have sought to deploy one or more stand-alone applications, ensure that these are working properly, and then think about how they might be extended and/or integrated with each other.
- Others have tried to get the network infrastructure, and/or a common platform for different applications in place first, and then to sort out how applications can be added or existing services integrated with it.

Moreover, relatively few implementations of smart city applications are fully deployed, operational, costed and budgeted solutions. Many accounts are about pilots, though this is not always clear, particularly as stories of deployments circulate and grow in the telling¹⁴. In addition, the term ‘pilot’

¹⁴ We were somewhat surprised to find that San Francisco’s much heralded smart parking scheme is a pilot, and one that has not been taken to full deployment for want of a business model to justify the investment. This is despite evaluations which show that the technology works and has achieved its declared objectives. See <http://www.sciencedirect.com/science/article/pii/S0965856414000470> or

actually covers a wide range of different kinds of implementation, from small-scale proof of concept demonstrations, through ‘Living Lab’ action research and development in a live environment, to full-scale tests of business viability.

- It is to be expected that some solutions will be piloted and then found wanting; that is, after all, the point of doing pilots. In cities, though, there are specific difficulties with moving from pilot to full deployment, even where the technology works and delivers the expected benefit.¹⁵
- In some cases, this is because that benefit does not translate into an ROI that can justify rollout; a smart parking scheme, for example, might reduce the amount of traffic congestion in the city centre but lead to a decline in revenues from fees and fines. This is exactly what seems to have happened in the case of San Francisco, where the smart parking implementation was successful in reducing ‘cruising time’ spent looking for parking but did not pay for itself. The UK city of Birmingham similarly found that its smart parking trial did not provide a business justification for deployment. In other words, for some smart city applications, the benefit can be quantified but only makes sense if they form part of an overall vision for the city.
- In other cases, there is an ROI that would justify roll-out, but no long-term budget that can support the investment. Here vendor financing, public private partnerships and central government financing may all have important roles to play. The Indian Government’s Smart Cities Mission, EU smart city programmes, such as the European Commission’s Horizon 2020 and its Smart Cities and Communities initiative (EIP-SCC), the US Federal Government’s smart cities initiative, and the Chinese Government’s National New Urbanisation Plan (2014-2020)¹⁶ are all illustrations of this.

This suggests that there are least three routes towards a mature smart city:

- An ‘anchor’ route, in which the city adds working applications in series. Here a city has a clear and pressing need for its ‘anchor’ application, to which others are then added as priorities dictate.
- A ‘platform’ route, in which the city focuses on deploying infrastructure first so that a number of applications can be delivered later
- A ‘beta city’ route, in which the city continues to experiment with multiple applications without a finalised plan for how to bring these pilots to full operational deployment. Beta cities accept that the currently available technologies and business models can only be provisional and prioritise hands-on experience over short-term or medium-term tangible benefits.

These advantages and disadvantages of each of these routes are illustrated below in Figure 2.

[https://people.ucsc.edu/~adammb/publications/Millard-Ball Weinberger Hampshire 2014 Assessing the impacts SFpark.pdf](https://people.ucsc.edu/~adammb/publications/Millard-Ball%20Weinberger%20Hampshire%202014%20Assessing%20the%20impacts%20SFpark.pdf)

¹⁵ There is a very full discussion of some of these issues in ‘Financing models for smart cities’ <https://eu-smartcities.eu/sites/all/files/Guideline-%20Financing%20Models%20for%20smart%20cities-january.pdf>

¹⁶ See http://www.gov.cn/gongbao/content/2014/content_2644805.htm especially Chapter 18.

Figure 2 Advantages and Disadvantages of Smart City Routes

	Anchor	Platform	Beta
+	<ul style="list-style-type: none"> • Short path to deployment • Concrete gains and easy to evaluate ROI • Use case driven 	<ul style="list-style-type: none"> • Synergies between applications are possible • Smooth path to integration • Future flexibility • Can engage third parties via APIs and open data • Capabilities and performance “by design” 	<ul style="list-style-type: none"> • Engagement with citizens and politicians • Access to funding for trials and research • Easy involvement of start-ups and small innovative companies • Opportunity to use many tools including consumer-grade internet applications (e.g. Twitter, WeChat)
-	<ul style="list-style-type: none"> • Future integration can be hard • Absence of synergies between applications 	<ul style="list-style-type: none"> • Absence of mature standards can make specification and choice hard • Risk of lock-in • Upfront investment without initial ROI from applications 	<ul style="list-style-type: none"> • Hard to go beyond pilot and achieve operational deployment • Diffusion of focus

For the avoidance of doubt, we do not believe that one of these three routes is the ‘right’ answer. Each has something to recommend it, and which one fits best will depend on the city’s resources, issues, and priorities. A ‘beta’ approach may deliver more visible ‘easy wins’ quickly. An ‘anchor’ approach might be absolutely determined by a single issue, such as preparations for earthquakes, which dwarfs all others.

Few cities are pursuing an absolutely pure form of one of these routes. Most have something of more than one route; either they are hedging their bets, or are in the process of shifting from one route to another. Several are at such an early stage that they have not yet settled down into one route or another.

4.4 Governance for the smart city

Institutional and governance frameworks vary widely. This is no surprise. The structures and powers of municipal authorities are very different across countries. But even within countries some cities have vested their smart city projects in a specific ‘smart’ department, or within an Innovation department, while others situated development within specific operational departments such as lighting or highway maintenance (in some cases these departments have created their own innovation teams). Some have sought to keep the smart city activity within the municipal organization; Shanghai is a good example of this. Others (such as Bristol, Vienna and Amsterdam¹⁷) have created special vehicles and joint venture companies to do so. The large-scale effort to create a number of smart cities led by the

¹⁷The somewhat complex structure of the Amsterdam SPV is illustrated at <https://amsterdamsmartcity.com/p/about>

Ministry of Urban Development in India makes the creation of special purpose vehicles with more commercial freedom than municipalities a condition of funding and almost an article of faith¹⁸; Pune, and Delhi, discussed below have necessarily taken this route.

4.5 The role of IoT

The centrality of data is a common theme across smart cities. However, not all cities have aimed to provide smart city applications based on this data themselves. Some have taken more of a ‘publishing’ approach, seeking to make available data they generate themselves, or to ‘curate’ data that is provided by others. Data can be provided either via open data portals or through paid-for data marketplaces; in both cases the expectation is that third parties may be better able to exploit the data than the city could itself. This approach has been pursued with great enthusiasm by the Greater London Authority¹⁹ and Transport for London²⁰, and by Barcelona²¹ and Bristol²² within our sample of cities. Seoul has taken this approach to another level, making administrative documents in the process of being drafted available to citizens through an ‘Information Communication Agora’²³

This data can come from many sources: from the operational procedures of the city’s agencies (such as demographic and household data, school rolls or highway repairs); from crowdsourced data actively contributed by citizens via smartphone applications, web pages and messages, or passively contributed by automated smartphone apps which make use of the devices’ embedded sensors; or from the IoT, those physical devices, vehicles, buildings, infrastructure and other items which have been embedded with electronics, software, sensors, actuators, and network connectivity so as to enable these objects to collect and exchange data.

As a specialist IoT analyst house, Machina Research has naturally chosen to focus the research for this report on those aspects of smart cities that are most closely aligned to the IoT. We are, of course, aware that some cities have different priorities and this will be reflected in the ways in which we have characterized their progress and achievements. See the section on methodology for scoring in Section 5.1 below.

¹⁸ <http://smartcities.gov.in/writereaddata/SPVs.pdf>

¹⁹ <https://data.london.gov.uk/>

²⁰ <https://tfl.gov.uk/info-for/open-data-users/>

²¹ <http://smartcity.bcn.cat/en/open-data.html>

²² <https://opendata.bristol.gov.uk/>

²³ <http://www.collaborativeconsumption.com/2013/11/22/seoul-shares-administrative-documents-with-public-even-in-process/>

4.6 Smart, Safe, Sustainable: a taxonomy of smart city applications

There is a very broad range of applications that have been associated with smart cities. There is no definitive taxonomy.

- As described above some providers, and some cities, emphasize applications intended to optimize the operation of the municipality's own services (lighting, waste collection, etc.).
- Others focus on services which are provided by the city but are intended to engage²⁴, attract or delight citizens. It is widely claimed that the availability of high quality fixed and mobile data connectivity, internet-enabled applications that allow the city to interact with its 'customers', and a willingness to embrace and adopt technology all help to make the city a more attractive place to live and locate a business.
- Some commentators include so-called 'bottom-up' applications, which are deployed within the city by businesses or through community initiatives²⁵ but are only loosely connected to the municipal authority²⁶. A notable hybrid approach is pursued by the UK city of Peterborough, which 'curates' a Freecycle-like network of businesses to encourage re-use of waste materials and reduce the burden on the city's waste disposal operations.²⁷

"Downtown Cleveland is transforming into a vibrant 24/7 hub of activity with new development, new amenities, new businesses and new residents."

- Mayor Frank G. Jackson

For this report we have grouped city-oriented IoT applications into three broad categories:

- Smart Living: IoT applications aimed at improving the quality of life for citizens. Included in this category are applications which are intended to stimulate or support economic development, thereby making cities more attractive places to live. This latter group are especially important for a group of declining industrial cities²⁸ in developed economies, where the city faces a shrinking population, reduced land values and a consequent diminution of the tax base.

²⁴ An important category here is e-Government, which is intended to allow citizens to interact with the municipality (e.g. pay bills and taxes) but also to interact and communicate with it to express opinions and preferences. An issue to consider here is the extent to which this can offset, or is related to in other ways, the declining trust (see for example http://www.eupan.eu/files/repository/20160202135959_2016-01-21_-_Public_integrity_and_trust_in_Europe_-_final.pdf) and participation in local politics (see <http://www.governing.com/topics/politics/gov-voter-turnout-municipal-elections.html> for a US perspective)

²⁵ Such as the Freecycle Network, which began in Tucson, Arizona, as a non-profit company aimed at saving re-usable goods from landfill and has since spread to other US and international cities.

²⁶ See for example "Rethinking Smart Cities From The Ground Up" (NESTA 2015) <http://www.nesta.org.uk/publications/rethinking-smart-cities-ground> and "Nordic Cities Beyond Digital Disruption" (Demos Helsinki 2015) <http://www.demoshelsinki.fi/en/julkaisut/nordic-cities-beyond-digital-disruption/>

²⁷ <http://www.peterboroughdna.com/circular-economy/>

²⁸ See <https://sites.google.com/site/shrinkingcitiesnetwork/>

- **Smart Safety:** IoT applications aimed at helping to prevent, or minimize the risks and impact of, adverse events including crime, accidents, environmental pollution and natural disasters. Included in this category are crowd management, pollution and pollen monitoring and notification alerts. The increasing prevalence of CCTV cameras for the surveillance of public places (driven in part by the declining price of such cameras) and the growing acceptance of body-worn cameras for the police, may also help contribute to making cities safer. Our focus on IoT applications means we would exclude communications equipment used by first responders but would include wearable devices intended to monitor their conditions and vital signs²⁹.
- **Smart Sustainability:** IoT applications intended to reduce the environmental impact (especially energy consumption and carbon emissions) of the municipality's own operations and the activities of business which operate within its jurisdiction and citizens who live there. There is often an emphasis on applications which support the microgeneration and distribution of renewable energy, and a 'modal shift' of transport from car driving towards other modes with less environmental impact

Figure 3 below presents some examples of smart city IoT applications in each of these categories. It is not an exhaustive list. It is also clear that some applications sit across more than one category; a citizen sensing project designed to collect information about noise levels³⁰ might be characterized as 'smart living' because it is about engagement, or 'smart sustainability' because it provides the municipality with crowd-sourced environmental monitoring.

Figure 3 IoT Smart city applications by category

Smart Living	Smart Safety	Smart Sustainability
<ul style="list-style-type: none"> • Connected signage • City applications to support tourism and culture • Event notification • Public WiFi • Connected street furniture 	<ul style="list-style-type: none"> • Smart care and assisted living • CCTV and Smart CCTV • Incident detection (e.g. gunshot monitoring) • Crowd monitoring and control • Adaptive lighting • Environmental monitoring (air quality, noise, pollen, water quality, flood monitoring) • Emergency alerts and notifications • Disease surveillance and epidemic monitoring 	<ul style="list-style-type: none"> • Energy management • Transport • Smart parking • Traffic management • Bicycle sharing • Smart lighting • Public space water management • Waste management

²⁹ Such as Mutualink's Wearable Smart Gateway, intended to be used by firefighters <https://software.intel.com/en-us/articles/the-wearable-smart-gateway-revolutionary-wearable-tech-for-first-responders>

³⁰ Like NoiseTube <http://www.citizensciencecenter.com/monitor-noise-pollution-with-your-mobile-phone/>

	<ul style="list-style-type: none"> • Building and infrastructure structural monitoring • Access control and perimeter surveillance 	
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5 City profiles

5.1 Scoring methodology

Below we present in-depth profiles of the 22 cities we studied for this report. Because cities demonstrate great diversity in their development of smart applications, the methodology needed to recognize all levels of activity including smart city planning, development of applications in a trial stage, and applications in full active roll-out. To this end a 'heat scale' approach was chosen that aimed to reflect overall IoT activity levels rather than a scale that measured smart application 'success'.

We assigned each application that we researched, and its related planning activity, to one of three broad categories of Smart, Safe, and Sustainable activity. In each case, we are interested in IoT activity, not other network infrastructure deployments that could be considered to support 'smartness', 'safety' or 'sustainability'. For each city, these three 'Smart Categories' have been assessed and an overall score applied on a six-point scale, from 0 to 5. Each score reflects the level of the city's activity in this area, with a higher number denoting a higher level of IoT smart city activity. While planning, trials and live applications all contribute to an overall score, live deployments carry greater influence than application plans.

To reach a final score, we have followed the following process.

- In settling on a provisional score we have examined the areas of IoT activity which we have allocated to each of the three categories, and considered whether they are planned, in trial or pilot, or in full operational deployment. In the first instance a simple scoring grid was used to help with applying a consistent approach between cities.
- Once all cities were scored on all three categories, all cities were then compared to eliminate any significant outliers and adjustments made.
- The revised scores were then reviewed again against the known city profiles to ensure that any other broad qualitative input was taken into account.

The scale approximates to the eight-point scale used by the TMForum in its 'Smart City Maturity and Benchmark Model'³¹. However, we note that the TMForum model distinguishes between three

³¹ <https://www.tmforum.org/smart-city-forum/smart-city-maturity-benchmark-model/>

different levels of plan development but does not make the same distinction as us in terms of pilots vs. operational deployments.

5.2 Auckland

5.2.1 Key figures

- Population: 1.4 million (2013).³²
- GDP per capita: NZD56,997 (2015).³³
- Unemployment: 5.4% (2013).³⁴

5.2.2 Portrait

- Located on New Zealand's North Island, Auckland is the country's most populous city.
- The city has an extremely diverse and growing population.
- Its economy is the largest in the country. Banking and finance, business services and international trade are amongst its key sectors.

5.2.3 Smart City

Auckland Council has recently been developing a strategic framework for its smart city activities. It covers six areas:

- open data
- innovation
- digital education
- public transport
- waste and energy efficiency
- communities.

Its interest in smart technologies lies, in particular, in:

- Helping it to empower and connect with its citizens and communities.
- Becoming a lower carbon city with reduced environmental impact as it grows.
- Improving the city's resilience.

The Council sees its role as facilitating projects and is looking to the commercial sector to propose solutions. However, the council is keen not to be locked into proprietary vendor solutions.

³²

<http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/reports/Documents/aucklandprofileinitialresults2013census201405.pdf>

³³

http://www.stats.govt.nz/browse_for_stats/economic_indicators/NationalAccounts/RegionalGDP_MRYeMar15.aspx

³⁴

<http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/reports/Documents/aucklandprofileinitialresults2013census201405.pdf>

It is also looking to develop policies and infrastructure that will enable it to collect usable data from its smart city projects.

Although it is at an early stage in exploring what being a smart city would look like for it, it is actively engaged in:

- looking for locations to do testbed projects
- thinking through which organisational structures will work best
- deciding how to co-ordinate projects internally
- considering how best to use external partnerships.

To date, the city has not developed metrics specific to smart city projects.

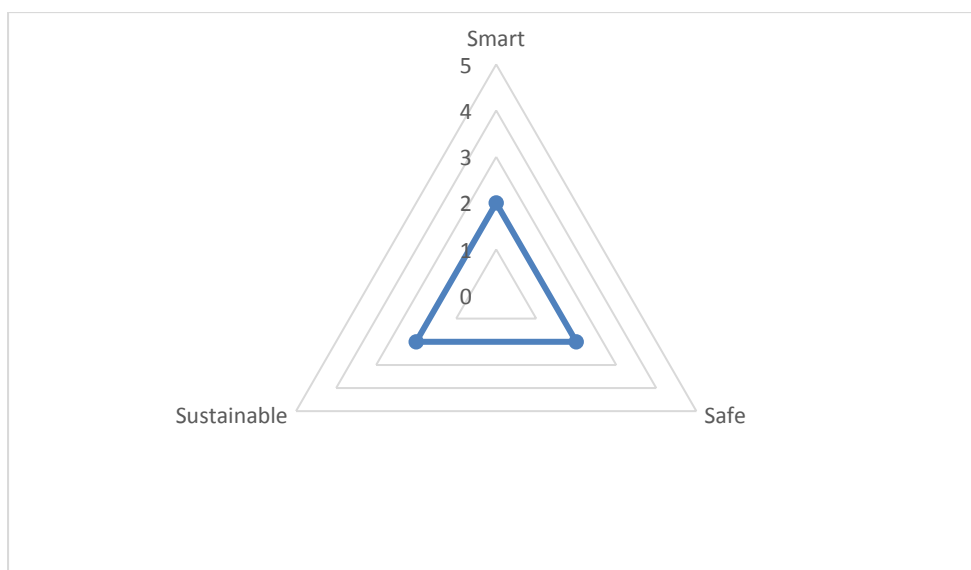
5.2.4 Key bodies

- **Auckland Council.**
- **Auckland Tourism, Events and Economics Development (ATEED).**

5.2.5 IoT applications planned, in development, implemented

All Auckland's smart city projects are currently at the planning stage. It has carried out an interesting multi-stakeholder market trial of broadband-connected bus shelters.³⁵

Smart city project area activity



The Council's efforts at the moment are focused on particular redevelopment areas, such as the Commercial Bay development and ATEED innovation space in Wynyard quarter. Neither of these have, to date, explicitly IoT smart city components.

³⁵http://ngconnect.org/wp-content/uploads/2016/03/PR1512017052EN_Innovation-2020-Connected_Bus_Shelter_Report.pdf

5.2.6 Key lessons

Auckland, though early in its smart city projects, has nonetheless identified a number of key lessons that it believes will be important for the success of its projects:

- Strategic framework. The city has put in place an overarching strategic framework to ensure its smart city projects deliver to common goals.
- Test beds. Auckland is seeking to tie in smart city projects with regeneration projects, which is a sensible approach as it provides larger budgets within which smart projects can be delivered. It also enables the city to test solutions in smaller, controlled environments before moving to city-wide deployments.
- Stakeholder co-ordination. By thinking through how best it can facilitate projects and how it can ensure internal departments will collaborate effectively the city is seeking to avoid potentially major roadblocks at later stages of implementation.

" We see the role of the council as facilitator. We're very interested in understanding what's worked well for other cities in terms of working with the private sector."

– Louise Mason, Head of Strategic Partnering, Auckland Council

5.2.7 Machina research view

- Auckland, which already scores very high on multiple 'liveability' indices, is at a very early stage in its smart city journey, but it is starting from a well informed and thoughtful perspective, with a clear strategic framework in place. It shows every sign of proceeding at a steady pace towards becoming a 'platform city'.
- Other early-stage cities could do well to look to Auckland's orderly approach to strategy development rather than rushing in to a one-off point solution that may be hard to integrate later.
- It is particularly keen to avoid vendor lock-in and could consider taking a leaf from Bristol's playbook, where the city has managed to ensure inter-operability and openness by maintaining multiple vendors and platforms for its trials and pilots. This is more work and may not be suitable for full operational deployment but works well at an early stage.

5.3 Bangkok

5.3.1 Key figures

- Population: 8 million (2010).³⁶
- Gross provincial product per capita: THB466,844 (2013).³⁷
- Unemployment: 1% (2016).³⁸

³⁶ <http://worldpopulationreview.com/world-cities/bangkok-population/>

³⁷ http://www.nesdb.go.th/nesdb_en/ewt_dl_link.php?nid=4317&filename=national_account

³⁸ <http://www.tradingeconomics.com/thailand/unemployment-rate>

5.3.2 Portrait

- Bangkok is the capital of Thailand and its largest city.
- Important sectors in its economy include tourism, finance, trade and manufacturing.
- The city suffers from significant air pollution, in part a consequence of extremely high levels of traffic congestion.

5.3.3 Smart City

Bangkok Metropolitan Administration (BMA) is responsible for the management of the city. This body comprises the role of Governor and the Bangkok Metropolitan Council.

A key driver for the BMA's smart city activities is its perception that its citizens want it to catch-up with other cities in Asia, such as Shanghai and Singapore, which are perceived as being further ahead in rolling out smart city projects.

To implement its smart city projects, the administration has tended to use a mix of in-house development and third-party vendors. Its projects typically require the involvement of many different government agencies.

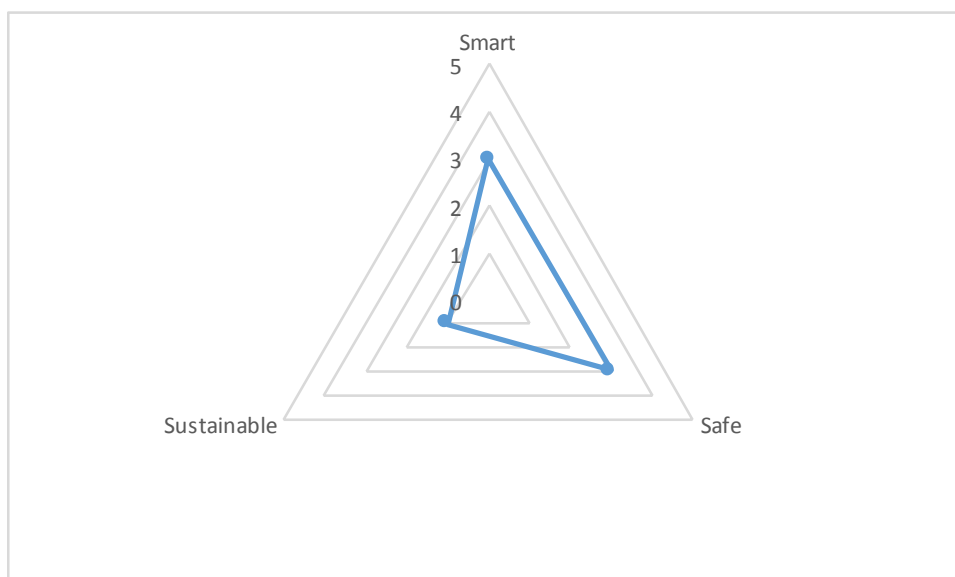
Key challenges for the city in implementing its smart city projects currently are:

- **Collaboration.** Finding a way to make a success of projects that need collaboration across both a number of different government agencies as well as with private sector.
- **Speed of implementation.** It's proving hard for the BMA to move fast enough to meet its citizens' expectations.
- **Open data.** Although data is collected real time there are currently no proper open data initiatives beyond alerting citizens of adverse weather. Consequently, it's not been possible for SMEs and start-ups to access the available data and so to create new and innovative applications.

5.3.4 IoT applications planned, in development, implemented

To date, Bangkok is most advanced in the area of safe and smart projects.

Smart city project area activity



Its key smart city projects include:

- Public WiFi.
- Environmental monitoring – sensors to monitor sound levels and air and water quality in order to help prevent pollution.
- CCTV.
- Intelligent transport systems – traffic lights at key junctions. Monitoring traffic levels as an input into planning to improve traffic congestion levels.

” The key consideration for us is whether potential projects are scalable and at what cost. Projects also have to be both targeted and impactful.”

– Prasopsook
Phimpagowit, Director,
Computer System
Control Division,
Bangkok Metropolitan
Administration

5.3.5 Key lessons

The key lessons learnt by the BMA to date include:

- **Assessing urgency.** It has found it to be important to carefully assess how urgent a problem that is being solved is before proceeding into trials and full deployments.
- **Understanding resource requirements.** Carefully understanding the level of resources required and the complexity of any potential solution before proceeding.
- **Project scalability.** The need to consider how scalable trial projects are and what the costs to do so will be.

5.3.6 Machina research view

- Bangkok is in an advanced region where there is much smart city activity, though perhaps not as much as the municipality itself perceives there to be. It inevitably compares itself to its neighbours and is concerned not to lag behind others which might be seen as more developed.
- It is currently pursuing a rather careful ‘beta city’ approach. There are a number of pilots ongoing, with relatively little attempt to secure synergies or integration.
- Its most advanced deployments are in the areas of ‘smart’ and ‘safe’, though it is tempting to conclude that the most pressing problems are in the area of sustainability. Bangkok is the second worst in the world for traffic congestion³⁹, though it does rather better in terms of air pollution⁴⁰. As an Asian ‘megadelta’ city it is particularly vulnerable to climate change, with impacts on drought, food security and rising sea levels. There are many mitigation and defence plans in place or in preparation, but as yet none seem to involve IoT. This seems like a missed opportunity.
- Bangkok has the potential for an easy win in the area of open data. It can learn from others and introduce a best-in-class portal.

5.4 Barcelona

5.4.1 Key figures

- Population: 1.6 million (2014).

³⁹ <http://bangkok.coconuts.co/2016/03/22/jammed-bangkok-second-most-congested-city-world-says-study>

⁴⁰ <http://www.air-quality.org.uk/11.php>

- Gross regional product per capita: unknown.
- Unemployment: 17.5% (2015).⁴¹

5.4.2 Portrait

- Barcelona is Spain's second largest city and the capital of Catalonia.
- The city has a diverse economy with important sectors including manufacturing, tourism and fashion.
- It also plays frequent host to large-scale conferences and trade fairs, with the large number of visitors placing particular strain on the local transport system.
- As in other Spanish cities, there is a very high level of participation in municipal elections and engagement with local politics. In May 2015 the city administration was captured by a coalition of leftist and Green political parties, displacing both of the main political parties that dominate Spanish politics and unseating the PSC Socialist party that had hitherto run the city.

5.4.3 Smart City

Barcelona is widely known as an early pioneer of smart city applications and its city council has invested significant time and energy into transforming Barcelona into a smart city. Its District 22@ regeneration area was one of the first to focus on technology-led regeneration and has become a model to follow for other cities.⁴²

The city kicked off its Smart City Strategy, in 2011 and in 2014 published its smart city 'Master Plan' to guide implementation of projects. It was an early adopter of 'participatory planning' aimed at allowing residents to vote on options for the redevelopment of certain roads and areas.⁴³

The council has set out well over 100 projects that it sees as offering the potential to:

- improve the efficiency with which its public services were delivered
- help protect the environment
- foster economic development in the city.

In addition, ensuring use of open data has been a central aspect of Barcelona's approach to its smart city transformation.

A mid-2015 change of administration in the city may be affecting the importance the council is affording its smart city initiatives. There have been suggestions that the new administration may be reviewing its involvement in smart city projects, but it is not yet clear how significant such a change in priorities is or the impact that it will have.

5.4.4 Key bodies

- **l'Ajuntament de Barcelona** – Barcelona City Council.
- **i2CAT Foundation** – research and innovation centre based in Barcelona.

⁴¹ Entire Catalonia region. Source: [EURES](#).

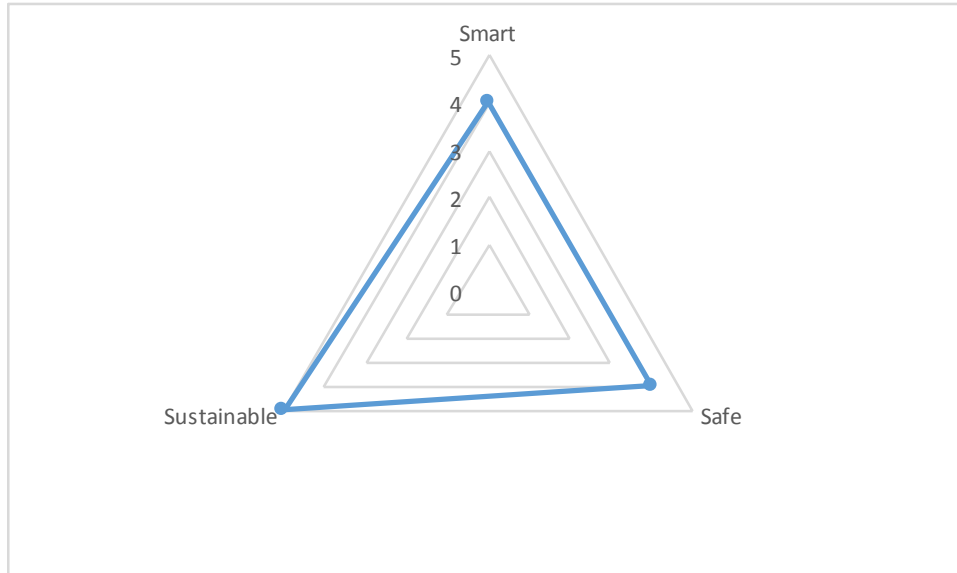
⁴² <http://www.22barcelona.com/>

⁴³ <https://arkinetblog.wordpress.com/2010/03/22/barcelona-will-vote-for-diagonal-redesign/>

5.4.5 IoT applications planned, in development, implemented

Barcelona has launched a very wide range of smart city projects across all three smart, sustainable and safe areas.

Smart city project area activity



Barcelona's smart city projects include:

- smart waste collection, with sensors monitoring levels in street rubbish bins.
- smart lighting.
- smart grid.
- energy monitoring and energy efficiency for buildings.
- smart mobility – including traffic management, smart parking and its 'Bicing' electric bike hire scheme.
- smart urban furniture – such as citizen information points.
- connected healthcare.
- 'Barcelona Wi-Fi' – i.e. public Wi-Fi.
- connected CCTV.
- environmental monitoring through sensor networks including monitoring water usage of public fountains.
- open government with city apps an open data platform designed to stimulate third-party application development and use of big data.

The city began development of its 'city OS' to provide a single platform through which it could manage its many smart city applications in 2015.

However, as noted above, it remains to be seen whether all these projects will continue to receive the priority and investment needed to ensure they continue to be developed.

5.4.6 Key lessons

Barcelona illustrates the following key lessons:

- **Leadership.** Having vision and strong leadership is critical to driving its smart city activities.

- **Public/private partnerships.** Use of public/private partnerships can be helpful in reducing the amount of public investment required.
- **Open data.** Stimulating third-party development of applications requires putting in place a suitable open data platform.

5.4.7 Machina research view

- Barcelona is a high profile smart city with lots of initiatives and trial smart services. It benefits from the well-developed association of smart cities in Spain and from the support that this receives from central and regional government and from Spanish corporates.⁴⁴
- It has pursued an 'anchor' type strategy but is moving, somewhat belatedly, towards 'platform' as it seeks to introduce its own city OS.
- It is driven by the problems of success, in that the large numbers of visitors it attracts put severe pressure on infrastructure. There is a growing perception that the influx of tourists has not been equally good for all citizens, and the new administration is taking note – for example, by a 'crackdown' on Airbnb renters⁴⁵.
- It is also driven by problems of failure, in that the long-term impact of the global financial crisis has severely depressed the Spanish economy and sharpened the requirements for economic stimulus. This makes finding a role for the city in nurturing technology-based start-ups more urgent.
- The association of the smart city programs with the ousted administration, which was seen as proposing technocratic solutions to the city's problems, is a challenge. The program's champions now need to show direct connections with the benefits for citizens' lives.

5.5 Berlin

5.5.1 Key figures

- Population: 3.5 million (2014).⁴⁶
- Gross regional product per capita: unknown.
- Unemployment: 12.6% of labour force (2015).⁴⁷

5.5.2 Portrait

- Berlin is the capital city of Germany and one of the country's 16 federal states.
- One of the key challenges for the city is how to manage a growing population and sustain a good quality of life for its inhabitants in particular in the context of pressure on housing availability.
- The city is well known for its vibrant tech start-up scene.

⁴⁴ <http://www.redciudadesinteligentes.es/>

⁴⁵ <http://www.spanishpropertyinsight.com/2016/07/07/barcelona-threatens-airbnb-others-fines-e600000/>

⁴⁶ Source: <https://www.statistik-berlin-brandenburg.de/home.asp>

⁴⁷ Source: <https://www.statistik-berlin-brandenburg.de/home.asp>

5.5.3 Smart City

In 2012 the federal states of Berlin and Brandenburg launched a new innovation which identified five clusters for the region:

- energy technologies.
- traffic, mobility and logistics.
- ICT, media and creative industries.
- health.
- photonics.

Since then the following additional cross-cluster topics have been identified:

- smart cities.
- industrial production (incl. industry 4.0 and IoT).
- clean technologies.
- electromobility.

On 21 April 2015 the Berlin Senate Department for Urban Development and the Environment published its *Smart City Strategy Berlin* report. This sets out a strategic framework for Berlin to become a smart city. It sets out five areas of action:

- smart administration and urban society.
- smart housing.
- smart economy.
- smart mobility.
- smart infrastructure.
- public safety.

Key objectives for Berlin's smart city projects are delivering cost-savings and improving the efficiency and usability of services.

Berlin is heavily involved in EU smart city programmes, such as the European Commission's **Horizon 2020** and its **Smart Cities and Communities** initiative (EIP-SCC). The city applied to become a Lighthouse City⁴⁸ with Bologna in 2015 and is currently preparing a new application with Amsterdam and Graz. It is also the site for the Berlin 5G test bed, where some of the technologies associated with next-generation mobile networks will be trialled.⁴⁹

5.5.4 Key bodies

Smart city projects in Berlin involve an unusually large number of different organisations including the Senate, industrial partners, the SME community as well as various research institutes. This is part due to there being relatively decentralised funding structures within Berlin and Germany.

Key players in Berlin's smart city scene include:

⁴⁸ <http://www.grow-smarter.eu/lighthouse-cities/>

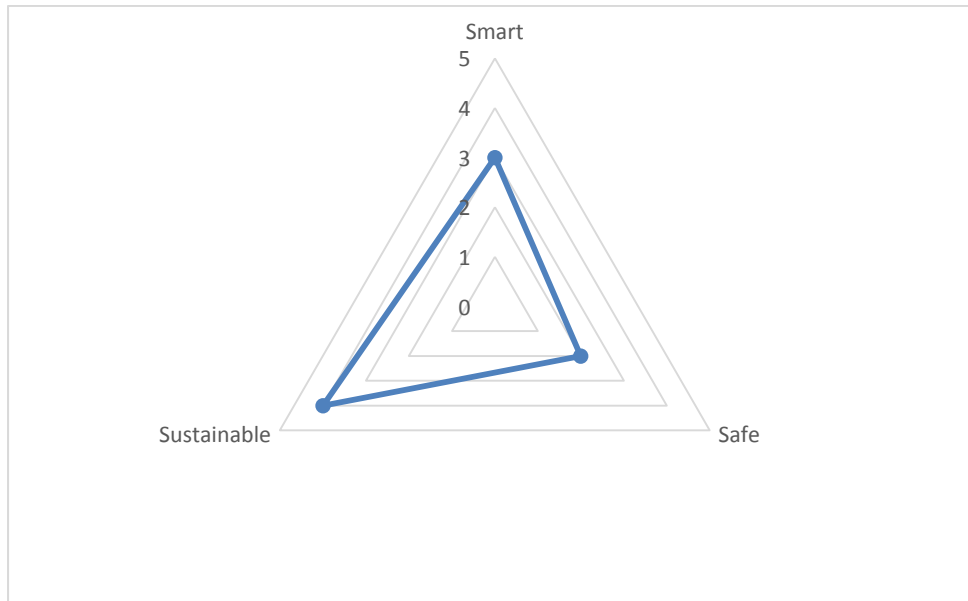
⁴⁹ <http://www.5g-berlin.org/>

- **Berlin Senate Department for Urban Development and the Environment.** Leads smart city initiatives. Sets high-level policy objectives in co-ordination with the **Mayor**, the **Senate Chancellery** and other Senate departments (such as the **Senate Department for the Interior and Sports** and the **Senate Department for Economic Affairs, Technology and Research**).
- **Berlin Partner for Business and Technology.** Business development agency for the federal state. Funded by the Senate and works closely with the Senate on the clusters and cross-cutting topics in the Berlin and Brandenburg states' innovation strategy.
- **Smart City Berlin Network.** Working group hosted by Berlin Partner for Business and Technology of over 100 companies and research institutes that are involved in smart city projects.
- **eMO Berlin Agency for Electromobility.** Operates under Berlin Partner for Business and Technology.
- Utility companies.
- **Berliner Verkehrsbetriebe (BVG).** Public transport company.
- **Berliner Stadtreinigungsbetriebe (BSR).** Waste management agency.
- **Berliner Wasserbetriebe (BWB).** Water company.
- **Technologiestiftung Berlin.** Technology think tank with particular specialism in big data and open data.
- **Fraunhofer Institute.** A research organisation.
- **TU Berlin.** University of Technology.
- **HTW Berlin.** University of Applied Sciences.
- **Investitionsbank Berlin (IBB).** Business development bank for state of Berlin.
- **BERLIN INNOVATION.** Showroom for technological innovation in Berlin.

5.5.5 IoT applications planned, in development, implemented

In its Smart City strategy, Berlin has identified some 30 or so smart city projects which it has begun, or is looking to pilot across the Smart, Sustainable and Safe areas.

Smart city project area activity



Many of these are at an early stage of development with, for example, pilots under way or planned for public WiFi, Pedelec e-bikes, healthcare, smart parking, traffic management, smart lighting, smart grids and environmental monitoring projects (amongst others).

There is also much work being done developing projects around intelligent and renewable energy in order to deliver Germany's EnergieWende (green energy transition) policy⁵⁰.

The Senate has also created a nascent open data portal, **Offene Daten Berlin**, which is designed to facilitate the sharing of data between organisations and citizens.

A key challenge for the city is identifying how to move effectively from pilots to sustainable roll-outs. The city has identified 10 locations in the city with the potential for redevelopment ('Zukunftsorte') which will be used as testbeds for different smart technologies prior to wider roll-outs.

5.5.6 Key lessons

- **Building an ecosystem.** In a city where responsibility and funding for smart city initiatives is decentralised, Berlin has found it critical to have a central organisation that facilitates co-ordination of projects, formation of consortia, sharing of best practice and to help to identify locations for testbeds. In Berlin this role is led by Smart City Berlin Network, within Berlin Partner for Business and Technology, in conjunction with the Senate departments.
- **Education on Smart City projects.** Individuals in procurement departments are not yet fully up to speed on issues around smart city projects. This makes it harder for them to evaluate smart city bids. To address this, initiatives such as the BERLIN INNOVATION showroom are being used to provide better information about the capabilities of smart city projects.

⁵⁰ For more information see <http://energytransition.de/>

- **Data sharing.** The best models for effective data sharing and how to encourage participation from organisations in the private sector is an issue that is being grappled with. The Offene Daten Berlin open data portal is an attempt to facilitate this. The senate is also looking to find good charging models for access – e.g. an open data marketplace with subscription access – as well as ensuring that data is high quality and readable by all parties so that services can be built out of these by e.g. start-ups. [Current project with Cisco, SAP and Fraunhofer institute]

5.5.7 Machina research view

- Berlin is a modern, well-resourced city with infrastructure, public transport, and cultural life that most other cities can only envy. It is successful in attracting young people from across Germany and the EU, while other parts of the country experience an ageing population.
- It has a strong overall vision that extends beyond the role of technology. It has a clear view of how it wants to be and how it plans to get there that includes an explicit commitment to keep city-centre housing affordable and to resist what other cities call gentrification⁵¹. Like Barcelona it has banned Airbnb.
- It is keen to be a start-up city with jobs and economic development provided by technology-based companies. It believes that this needs an appropriate communications infrastructure, but that it also needs to be liveable and affordable in order to attract and retain the creative people that this entails.
- Other cities can look to Berlin for lessons in co-ordination across multiple departments; Berlin might learn from others more about how to move from pilots and trials to full operational deployments.

5.6 Bogota

5.6.1 Key figures

- Population: 9.1 million (2014).⁵²
- GDP PPP adjusted: USD 159.9bn (2014).
- Unemployment: 8.7% in 2015.⁵³

5.6.2 Portrait

- Bogota is the capital city of Colombia.
- The city accounts for approximately 25% of the country's GDP with key sectors including life sciences, agribusinesses, technology and oil & gas.

5.6.3 Smart City

Establishing Bogota as a smart city is a priority for the city's leadership. The authorities are looking for projects in order to position the city internationally as an innovative city by 2025.

⁵¹ <https://www.ft.com/content/7f3dcfea-8a1b-11e6-8cb7-e7ada1d123b1>

⁵² <https://www.brookings.edu/research/global-metro-monitor/>

⁵³ <http://colombiareports.com/bogota-economy-statistics/>

Initially the Mayor's team develops ideas for inclusion in the District Development Plan, this document is then taken to the Council of Bogota where it is then considered or debated by councillors of the districts of Bogota.

Once agreed the most relevant secretariat is responsible for articulating and defining the roadmap for the implementation of the plans, programs and projects in question. In the case of smart cities, it is the District Planning Department who establishes the processes and the roles that the other ministries or sectors will play in implementing the program. The "Bogotá, smart city" program is outlined in Article 48 of the 2016-2020 Development Plan.

The High Council District of ICT launched its Master Plan ICT (PMTIC) in March 2015 in conjunction with Pontificia Universidad Javeriana with the objectives to improve digital services in the city and raise citizens' ICT skills. The council is looking to involve the local districts, private sector, academia and local citizens too.

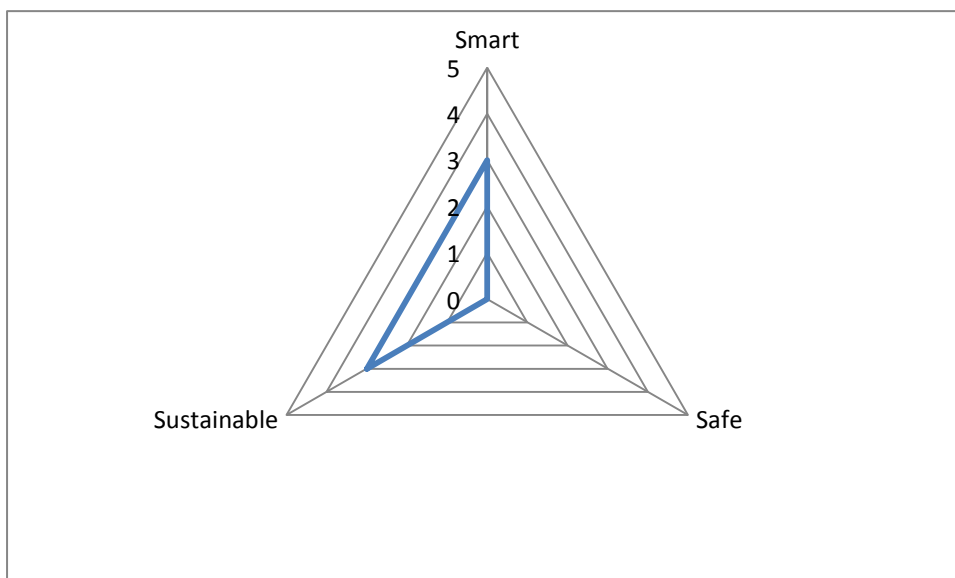
5.6.4 Key bodies

- Council of Bogotá.
- District Planning Department. Responsible for the processes to deliver smart city projects.
- The High Council District of ICT monitors new technological trends aimed at improving the quality of life of residents. It is responsible for digital projects and for making Bogota an intelligent city, encouraging the adoption of ICT and promotes the use of free software.
- The Infrastructure of Spatial Data for the Capital District (IDECA) facilitates the production of and access to geographic information inside the Capital District.
- TransMilenio, Bogota's bus rapid transit system.

5.6.5 IoT applications planned, in development, implemented

Bogota has launched a number of smart and sustainable projects several of which involve the creation of centralised platforms.

Smart city project area activity



Bogota's main smart city activities comprise:

- **Data Platform.** The IDECA is collating the city's geospatial information onto a cloud-based platform that was created in 2014. This provides the city's departments (health, education, culture, trade, tourism, social security, environment, public space) with a single view of property related information.
- **Public Wi-Fi.** Bogota has introduced wireless internet public places and is also encouraging citizens to create mobile apps to support smart city endeavours at its ViveLab.
- **Cycling.** TransMilenio launched a bike share program in 2014.
- **Traffic management.** To monitor congestion and keep traffic flowing Bogota's Mobility department launched an IoT traffic management platform in December 2015 that integrates data from street cameras, traffic lights and bike routes.
- **TransMilenio** has encouraged citizens to make fewer journeys by car to reduce congestion and pollution in the city. The department created more bus lanes as well as introduced hybrid and electric buses.

5.6.6 Key lessons

- **Smart city and social transformation interlocked.** A knowledge economy requires proactive policies and actions that promote science, technology and innovation for achieving a productive and social transformation.
- **Social Impact is the key criteria.** The districts deliver social projects, rather than commercial projects, which are not evaluated using financial indicators. A project's success is measured by its efficiency, efficacy and effectiveness in its execution.
- **Data at the heart of its decision making.** Bogota has taken steps to create the right environment for a smart city by putting data at the heart of its decision making. A coordinated approach by the different departments has laid the foundations for the city to achieve its objectives.

5.6.7 Machina research view

- Bogota is an emerging-market city where the central and local government has strong social and economic development priorities. These are the emphasis of its smart city strategy.
- The centrality of this within the overall mission means that, unusually, there is not much requirement for conventional metrics of success, in terms of ROI. This has made it easier to move towards service launches where other cities might have hung back.
- There is also strong focus on transport and traffic congestion.
- Bogota, like some other cities, has made use of the local university academics to provide much-needed expertise.

5.7 Bristol

5.7.1 Key figures

- Population: 449,000 (2016).⁵⁴
- GDP per capita: £23, 962 (2014).⁵⁵
- Unemployment: 5.4% (2015).⁵⁶

5.7.2 Portrait

- Bristol is the largest city in the South West of England.
- Alongside its two universities, key sectors of Bristol's economy include aerospace, manufacturing, high-tech and creative.
- Formerly a dock, the Harbourside area of Bristol has undergone significant renovation in recent decades in order to become an attractive retail, entertainment and tourist destination.

5.7.3 Smart City

A key factor in Bristol's approach to its smart city projects has been Bristol City Council's historic ownership of an existing duct network, on which much of its smart city applications have been built⁵⁷. Through Bristol is Open, a joint venture launched in 2015 between the Bristol City Council and Bristol University, the city has deployed a fibre-optic backbone network that runs software-defined networking (SDN) and a wireless mesh network.

This city has been aided in this by winning, in October 2015, EUR25 million in funding to become a Lighthouse City as part of the EU's Horizon 2020 Smart Cities and Communities innovation programme.

For Bristol, becoming a smart city is about using technology to enable the population to work more effectively and to enable the council to deliver services more cost-effectively.

The key smart city challenges for the city at its current stage of development are:

- **Implementation.** How to ensure all its smart city projects will connect together in a flexible and scalable way?
- **Finance.** Who will fund the full-scale roll-out of projects?

The city is in the process of deciding what the best metrics will be as it turns to evaluating its pilot projects and Bristol is Open is currently exploring what the best business model for it will be as it evolves.

⁵⁴ <https://www.bristol.gov.uk/statistics-census-information/the-population-of-bristol>

⁵⁵ <http://www.bristol.org.uk/industry/>

⁵⁶ <https://www.bristol.gov.uk/documents/20182/33191/Bristol+Econominc+Briefing+Sept+2016/e171a9ee-8da6-427e-825d-3a06b7f48861>

⁵⁷ The network was built in the 1970s to deliver cable TV and subsequently bought by the city with the aim of providing internet access to schools and council facilities.

Beyond its strictly smart city projects, the city is also home to initiatives such as Watershed's 'Playable City'⁵⁸ project, which encourages the development of games that foster a playful interaction with the infrastructure of city, using ICT.

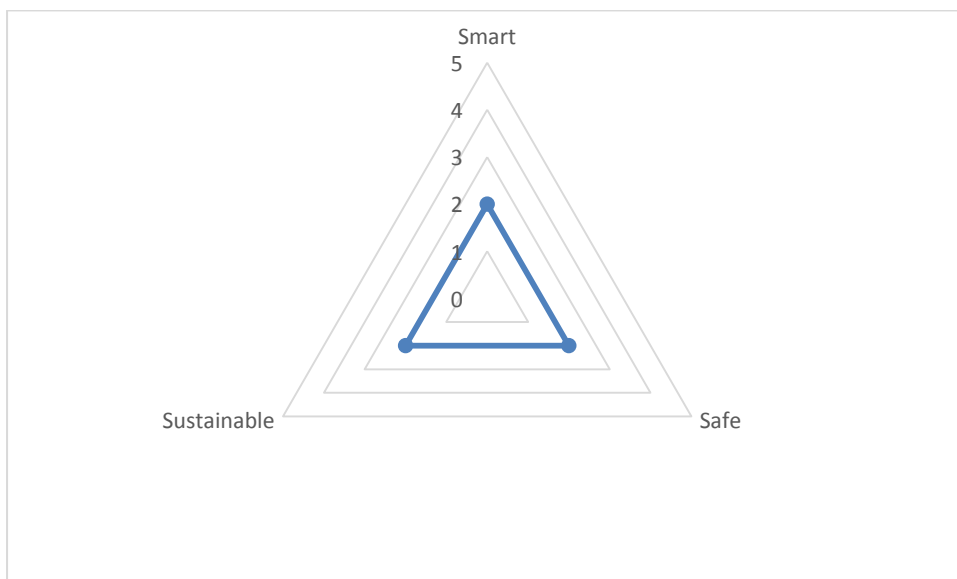
5.7.4 Key bodies

- **Bristol City Council.**
- **Bristol is Open.** Created in 2015. A joint venture between Bristol City Council and the University of Bristol. An R&D testbed that leases infrastructure from Bristol City Council.
- **Bristol University.** Joint venture partner with Bristol is Open.

5.7.5 IoT applications planned, in development, implemented

Bristol is in the early stages of carrying out smart city project trials and Bristol is Open is just beginning to think about how its pilots – which span smart, sustainable and safe areas – can be developed into full-scale city applications.

Smart city project area activity



Its current smart city project trials include:

- Public WiFi (mesh network) and street lighting – Bristol is Open trial projects.
- Smart waste management. Bristol is Open trial using NEC's Kite Flexible Sensing platform.
- Environmental monitoring – air quality sensor network.
- Traffic management system.
- Assisted Living – SPHERE research project (University of Bristol, University of Reading and University of Southampton).
- Open Data Portal⁵⁹ – an initiative of the city council rather than Bristol is Open, which publishes a rapidly-growing number of data sets.

⁵⁸ <https://www.playablecity.com/cities/bristol/>

⁵⁹ <https://opendata.bristol.gov.uk/>

In addition, Bristol University has been carrying out detailed analytics on the data generated during the trials with a view to using this to help identify future services and applications.

5.7.6 Key lessons

Some of the key lessons learnt by Bristol to date include:

- **Ownership of the physical network.** Bristol believes that its approach of first creating the physical network that will underpin individual smart city applications is key. Bristol also makes much of the fact that its infrastructure is a software defined network (SDN). This approach provides the city with the bandwidth, and the flexibility, that it will need in future. It sees this as essential to the success of its smart city ambitions.
- **Avoiding vendor lock-in.** A priority for Bristol is Open has been to avoid the city being locked into any single vendor's platform. It is currently discussing a number of different approaches from vendors to provide it with a platform that avoids this becoming an issue.

"Cities need to think about putting in place the right infrastructure and connectivity first as the bandwidth requirements of some applications are likely to be huge. We think SDN is really important and the right way to go."

- Jessica Ellis, Director of Customer Success, Bristol is Open

5.7.7 Machina research view

- Bristol is the quintessential 'Beta City'. It has many project and pilots progressing in parallel, and takes a Living Lab approach rather than focusing on a more formal path to making applications part of the city's ICT infrastructure. It is an enthusiastic participant in the European Network of Living Labs (ENOLL⁶⁰)
- Its special purpose vehicle Bristol is Open has successfully avoided any repercussions for smart city activities from the change in the political complexion of the mayor as well as making it easier to enter into new kinds of relationship with commercial companies that bypass formal procurement requirements. Other cities would do well to study this.
- More than most other cities Bristol has made avoiding vendor lock-in an absolute requirement. It has done so in part by engaging with the detail of data formats and APIs, something other cities have sometimes been reluctant to do. The involvement of university academics with detailed technology knowledge has been key to this; and the availability of its own physical network infrastructure has been part of the 'lure' for these academics.
- It has experimented in parallel with two application platforms from two vendors and driven both hard to maintain interoperability. Other cities could benefit from this approach, but should recognise that it is resource-intensive and may not transition well to a post-beta phase.

⁶⁰ <http://www.openlivinglabs.eu/livinglab/bristol-living-lab>

5.8 Cape Town

5.8.1 Key figures

- Population: 3.7 million (2011).⁶¹
- GDP per capita: ZAR58,844 (2012)⁶², USD14,086 (2014)⁶³.
- Unemployment: 23.8% (2011).⁶⁴

5.8.2 Portrait

- Cape Town is South Africa's second largest city by population and the capital of the Western Cape, coastally located and dramatically framed by Table Mountain.
- Important economic sectors for the city include tourism, manufacturing, finance, IT, transport and logistics.

5.8.3 Smart City

Cape Town is in the early stages of rolling out smart city projects. It has in place a Digital City strategy with four key pillars:

- **Digital Infrastructure** – Improving its broadband infrastructure to reduce the digital divide.
- **Digital Inclusion** – Increasing access to services over the Internet to promote inclusion, including through providing training basic computer skills.
- **Digital Government** – Rolling out e-Government services to improve transparency, deliver services more efficiently and promote citizen engagement.
- **Digital Economy** – Supporting the digital economy.

Many of its 'smart city' initiatives lack an IoT component – though they are no less important for that. For example, part of its 'Digital Inclusion' pillar is around providing training to increasing computer literacy.

5.8.4 Key bodies

- City of Cape Town.
- Western Cape Department of Economic Development and Tourism (DEDAT).
- Accelerate Cape Town. Business leadership organization that works to support the City of Cape Town in its Digital City strategy.
- Silicon Cape. Networking forum fostering a tech ecosystem in the Western Cape.

5.8.5 IoT applications planned, in development, implemented

Cape Town is most advanced in the smart category of smart city projects, but also has a smart grid trial projects in the safe category.

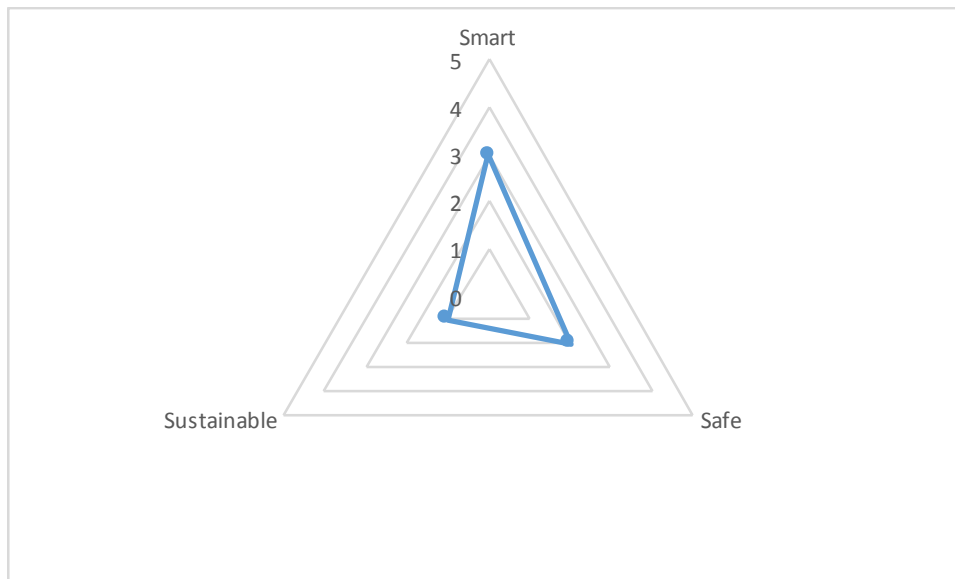
Smart city project area activity

⁶¹ https://www.capetown.gov.za/en/stats/Documents/City_Statistics_2012.pdf

⁶² <https://www.capetown.gov.za/en/stats/CityReports/Documents/SOCT%2014%20report%20complete.pdf>

⁶³ <http://businesstech.co.za/news/general/82201/joburg-vs-cape-town-best-city-challenge/>

⁶⁴ https://www.capetown.gov.za/en/stats/Documents/City_Statistics_2012.pdf



Its principal smart city activities have, to date, included:

- **Public Wi-Fi.** Being rolled out during 2016.
- **CCTV.** With 560 cameras located throughout the city.
- **Open Data Portal.** Launched in 2015.⁶⁵
- **Smart grid.** Several pilots underway through DEDAT.

5.8.6 Key lessons

Cape Town is very early on in its smart city programmes. Nonetheless, two key lessons may be identified:

- **Locality.** Cape Town is adopting an approaching suitable to its local context. Rather than pursuing grand projects that its citizens cannot benefit from, it is tailoring its efforts to what it perceives are their needs.
- **Training.** The city has made strong efforts in investing in the less glamorous, but necessary work of providing basic training to ensure that people in the city are equipped to make use of digital services as they are introduced.

5.8.7 Machina research view

- Cape Town's smart city strategy is at present not focused on IoT opportunities.
- The main emphasis is on e-Government to provide better access to and more efficient delivery of human facing services.
- Providing social and economic development by improving ICT skills is also an area of priority. This accounts for the city's relatively high 'smart' score.
- Cape Town has much to learn from other cities about the potential of IoT applications to make the city's operations more efficient and improve the lives of its citizens. It could do worse than

"The City of Cape Town is... using digital tools to enhance the quality of the organisation's engagement with residents. This enables the City to be a caring and responsive government."

– André Stelzner, Director, Information Services & Technology

⁶⁵ <https://web1.capetown.gov.za/web1/OpenDataPortal/>

‘copy with dignity’ some implementations and trials that are deployed elsewhere – for example, in smart street lighting, environmental monitoring or traffic management.

5.9 Cleveland

5.9.1 Key figures

- Population: 2mn (2014).⁶⁶
- GDP PPP: USD 115bn (2014).
- Unemployment: 19.2% (2014).⁶⁷

5.9.2 Portrait

- Traditionally the steel and manufacturing sectors were the bedrock of Cleveland’s economy. However, since 1980 Cleveland has lost over 150,000 manufacturing jobs.
- Unlike other declining industrial cities in the United States, Cleveland has successfully transitioned away from sunset industries and established a burgeoning healthcare cluster.
- The largest private employer in the city is the Cleveland Clinic, which has a workforce of over 37,000 and has had success in identifying and funding health care technology firms.
- Between 2011 and 2015 \$8 billion was invested in developing Cleveland including new hotels, residential buildings, public spaces, the arts and technology infrastructure.
- AT&T has spent \$350mn over three years establishing their Cleveland area network

5.9.3 Smart City

In February 2016 Cleveland published its Beyond Traffic: The Smart City Challenge Smart City Cleveland⁶⁸ report as part of its entry to the White House’s US smart cities competition which was won by neighbouring city Columbus.

The city’s plans include improving residents’ opportunities to find work, reduce greenhouse gas emissions and increase sustainable transport options.

Smart City Cleveland is comprised five strategic programs:

- **Smart Traffic.** 38 priority corridors will be equipped with pre-emption/priority devices to regulate the flow of traffic.
- **Smart Transit.** Manage the public transportation system with real-time data.
- **Smart Sensing.** Monitoring emissions, streetlights, and parking.
- **Smart Communications.** Develop smart kiosks, innovative applications and communication tools.
- **Smart Grid.** Improving street lighting and facilitate the use of electric vehicles in the city.

The preliminary budget for the programs comes to USD36 million.

⁶⁶ <https://www.brookings.edu/research/global-metro-monitor/>

⁶⁷ <https://www.transportation.gov/sites/dot.gov/files/docs/OH%20Cleveland.pdf>

⁶⁸ <https://cms.dot.gov/sites/dot.gov/files/docs/OH%20Cleveland.pdf>

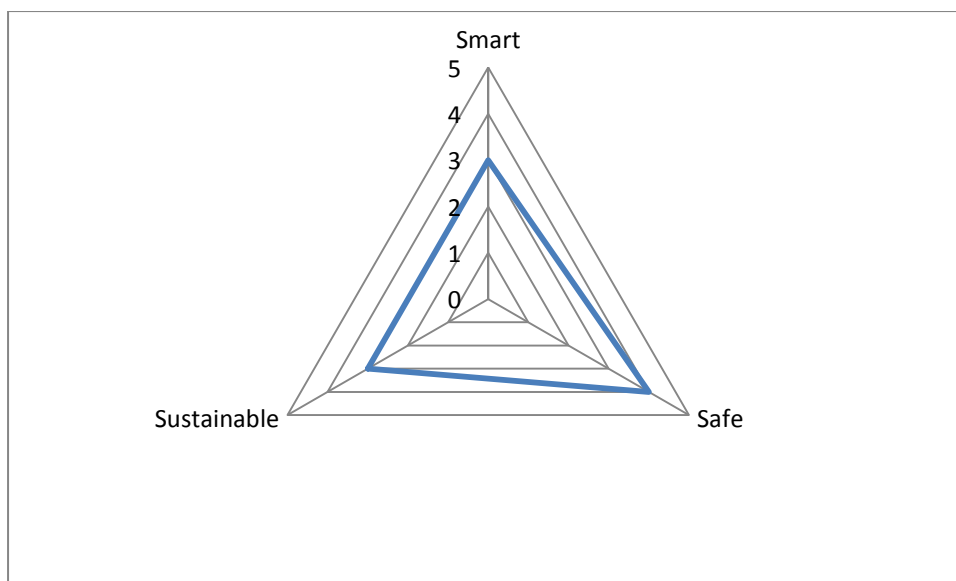
5.9.4 Key bodies

- **Greater Cleveland Regional Transit Authority (GCRTA)** is the region's public transit service provider and the sub-recipient of the Smart City Cleveland grant.
- **Northeast Ohio Areawide Coordinating Agency (NOACA)** is the region's metropolitan planning organization.
- **Ohio Department of Transportation (ODOT)**, will collaborate with Smart City Cleveland partners to provide data on standard signal design components such as vehicle detection, cabinet and controller types, communication methods.
- **Cleveland State University's University Transportation Center (CSU-UTC)** will be the primary resource for preparing transportation personnel.
- **National Aeronautics & Space Administration (NASA) Glenn Research Center** help develop materials that can operate in extreme temperatures.
- **Office of Sustainability.** Its priority areas are energy efficiency, local foods, renewable & advanced energy, clean water, sustainable mobility and zero waste.

5.9.5 IoT applications planned, in development, implemented

Cleveland has ambitious plans to introduce smart, safe and sustainable projects.

Smart city project area activity



The majority of Cleveland's smart city activities are at the planning stage.

- **Regulating traffic flow.** The city plans to install devices on priority traffic routes that can change traffic signals when emergency services are responding to incidents.
- **Autonomous vehicles.** The City and GCRTA will partner with the NASA Glenn to implement autonomous vehicle coupled with the infrastructure technology to assist in preventive and predictive vehicle maintenance.
- **Open data.** The City Planning Commission hosts a GIS portal to allow users to extract spatial information.

- **Smart kiosks.** Plans for the kiosks to enable citizens to connect with emergency services, receive public announcements and travel time information, public Wi-fi connectivity and the ability to charge mobile devices.
- **Fire and environmental monitoring.** Systems measuring quantitative chemical particles in the atmosphere.
- **Cycling.** Thus far the only IoT related application related to have emerged from the Sustainable Cleveland initiative is a bike share scheme that went live in September 2016.
- **CCTV.** Launched in 2013, the Cleveland's Shared Security Surveillance (CS3) program which utilises public and private cameras has been credited with a drop in crime rates.

In 2013, Clean Fuels Ohio released an electric vehicle (EV) readiness plan for the State of Ohio. The number of EVs in the Cleveland MSA is projected to exceed 10,000 by the year 2020, and rapidly expand to over 100,000 by 2030. Over 80% of drivers commute less than 50 miles a day in the Cleveland MSA, well within the range of all-electric vehicles in the market today

5.9.6 Key lessons

In order to mitigate the effects of the declines in the manufacturing sectors Cleveland has focussed on establishing a healthcare cluster. The smart city projects that have been planned so far will build on the investments made in the city communications infrastructure and should encourage more developers to create smart city solutions.

5.9.7 Machina research view

- Although at an early stage compared to most of the other developed-world cities covered in this study, Cleveland's vision for a smart city is much more aligned with IoT initiatives.
- There is a strong emphasis on transport and environmental monitoring. The car-centric transport policies prevalent in the US mean that even in an area of economic decline traffic management is a priority.
- There are also several safety-oriented projects, including fire detection, and CCTV for crime prevention.
- However, there is surprisingly little focus on citizen engagement, except as recipients of published information. The city could look to its counterparts in Europe and other developed regions for lessons in how to build awareness of and participation in emerging services. The Living Lab paradigm which emphasises co-creation with citizens could perhaps be applied here.
- Cleveland is behind a number of cities in this study. The city has some ambitious pilot projects; if successful they will enable the city to catch up.

5.10 Delhi

5.10.1 Key figures

- Population: 19 million.⁶⁹

⁶⁹ <http://worldpopulationreview.com/world-cities/delhi-population/>

- Gross regional product per capita: USD3,580 (2013).⁷⁰
- Unemployment: unknown.

5.10.2 Portrait

- The northern Indian city of New Delhi is the capital of the country and its second largest, by population, after Mumbai.
- Its population and economy are both growing rapidly.
- Beyond politics – a major source of employment – significant areas of the city's economy include finance, telecoms, IT and tourism.

5.10.3 Smart City

New Delhi is currently in the early stages of implementing an ambitious set of smart city projects.

A key enabler of New Delhi's efforts to become a smart city has been Prime Minister Narendra Modi's launch, in mid-2015, through the Ministry of Urban Development, of his national 100-city 'Smart Cities Mission' programme. In January 2016 the New Delhi Municipal Council (NDMC) – responsible for the 'Lutyen's Delhi' area of New Delhi – was one of 20 city projects chosen from across the country to be in the first round of this programme.

The NDMC plans to use its smart-city projects to address a number of areas that, following an extensive consultation process, it has identified as key 'pain points' for its citizens. These include:

- **Improved infrastructure** – including water, electricity and Internet access.
- **Social development** through improving healthcare and education services.
- **Greater inclusivity** with better access to services.
- **Urban mobility** through improved public transport, smart parking and more non-motorised vehicles.
- **Reducing pollution** – in particular lowering greenhouse gas emissions.

The city is making its own funds available, supplemented by those from central Government and PPP. It also has plans to raise revenue from services, for example through parking charges and advertisements on digital hoardings.

Its overall smart city goal is to establish New Delhi as the global benchmark for a capital city through:

- Improving the quality of life of its citizens and visitors.
- Improving the environment.
- Supporting economic development.

During 2016, the NDMC has established its special purpose vehicle (SPV) through which it will implement its smart city projects and begun to issue individual project RFPs.

5.10.4 Key bodies

- **New Delhi Municipal Council (NDMC)** – one of Delhi's five Urban Local Bodies.
- **New Delhi Municipal Council Smart City Limited** – SPV for rolling out New Delhi's smart city projects.

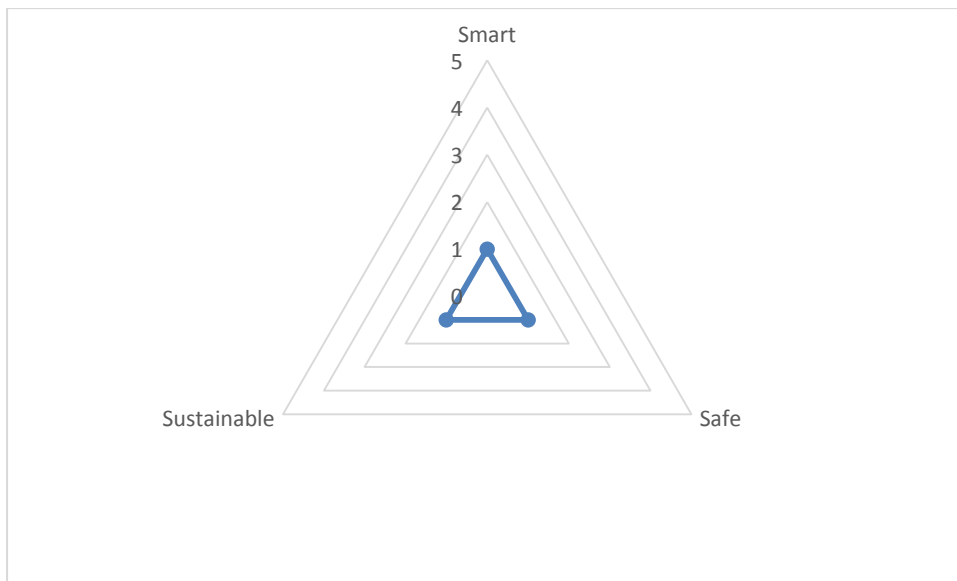
⁷⁰ https://www.brookings.edu/wp-content/uploads/2015/01/bmpp_GMM_final.pdf

- **Ministry of Urban Development** – ministry in the national Government leading the national Smart Cities Mission.

5.10.5 IoT applications planned, in development, implemented

All the NDMC's smart city projects are currently in the very early stages of being rolled out. Nonetheless, they are extensive and cut across all three of the smart, sustainable and safe areas. Progress is likely to be rapid through 2017 as trials get underway.

Smart city project area activity



The NDMC itself groups its smart city initiatives into three categories. These are:

- **Physical infrastructure** – e.g. traffic infrastructure.
- **Social infrastructure** – e.g. inclusion.
- **Value infrastructure** – e.g. signage and behavioural change.

Its planned IoT smart city applications fall predominantly into the physical infrastructure category. They include:

- Urban mobility and smart parking.
- Smart water and waste management.
- Smart grid and energy management.
- Sensor-based utility ducts.
- Rooftop solar panels.
- Command and control centre with CCTV surveillance.
- Smart lighting poles including city-wide public Wi-Fi access points, air-quality and noise-pollution sensors.
- Digital information and advertising hoardings.
- E-governance.

- Smart healthcare.
- Smart education – eLearning as well as mentoring and skills development.

5.10.6 Key lessons

The key lessons learnt by New Delhi at this stage of its smart city transformation are:

- **Consultation.** By consulting widely, with many different stakeholder groups, it's possible to ensure that smart city plans will meet the needs of citizens.
- **Data-backed decisions.** Underpin policy decisions with carefully analyse all available data.
- **Funding.** Carefully match projects to available levels of funding to avoid disappointing stakeholders by being overambitious and under delivering.

5.10.7 Machina research view

- Delhi is a megacity with problems of growth and an over-stretched infrastructure. At the same time, it has many technology and skill assets.
- Its smart city activities are at an early stage but its vision and plans are well defined and scoped. It has intentions to roll out many IoT oriented projects.
- Its program has strong support from central government which is highly focused on using technology as an agent of economic development.
- Like other cities it has identified a specific area as a focus for trials; somewhat controversially this is an affluent area rather than one in need of regeneration. The temptations of this are obvious, but so are the risks, in that smart city initiatives may come to be seen as something that do not benefit the majority of citizens.

5.11 Dubai

5.11.1 Key figures

- Population: 2.6 million (2016).⁷¹
- GDP per capita: USD43,963 (2014).⁷²
- Unemployment: 0.3% (2014).⁷³

5.11.2 Portrait

- Dubai, located on the Persian Gulf, is the capital city of the Emirate of Dubai within the UAE.
- Significant sectors of its diversified economy include tourism (with a high-end retail sector), trade (the city is a major port), construction, banking, IT and finance.

5.11.3 Smart City

Dubai launched its Smart Dubai smart city initiative in early 2014. Its stated aim is to use smart technology in order to make Dubai the happiest city on Earth.

⁷¹ <http://www.dubai-online.com/essential/population/>

⁷² <http://www.indexmundi.com/facts/united-arab-emirates/gdp-per-capita>

⁷³ <https://www.dsc.gov.ae/en-us/DSC-News/Pages/Dubai's-Unemployment-Rate-.aspx>

The initiative is built on six key pillars:

- **Economy.**
- **Living** – i.e. buildings, signage, healthcare.
- **Governance.**
- **Environment** – including utilities.
- **Mobility** – i.e. transport infrastructure.
- **People** – i.e. education.

As part of this initiative, the Dubai Smart City Project, running through to 2017, is rolling out a range of smart city applications. These are currently focused around on a number of key sites including:

- World Expo2020 site.
- Dubai Silicon Oasis Authority. Government-owned technology park that is an important testbed for Dubai's smart applications.
- Dubai Parks, a theme park resort.
- Desert Rose Housing Project, due for completion in 2020.
- Dubai Design District.

The city has introduced a 'Happiness Meter' so that citizens can provide feedback on their experience – either satisfied, neutral or dissatisfied – as they engage with Dubai's smart services.

5.11.4 Key bodies

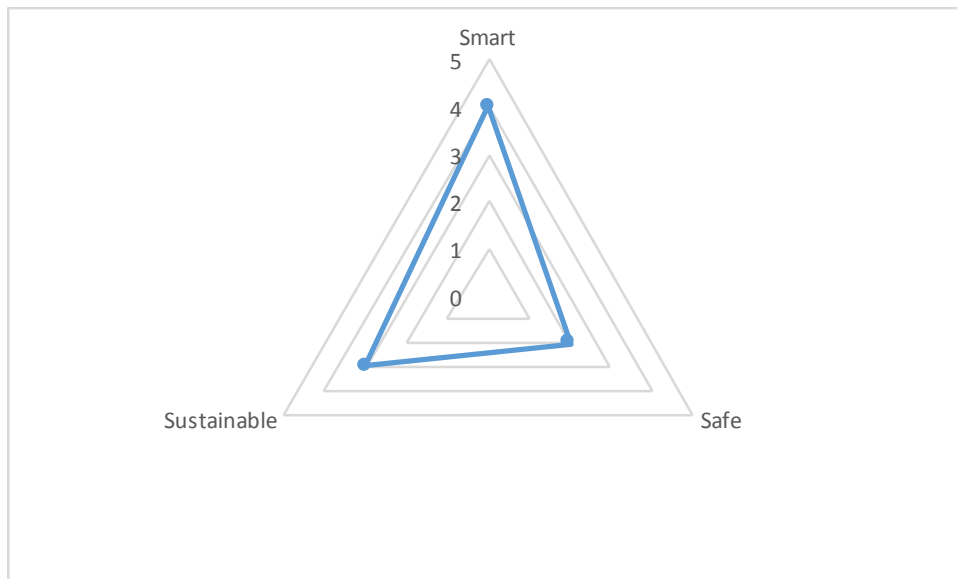
- **The Executive Council.** Responsible for the strategic plan and budget.
- **Dubai Municipality.**
- **Smart Dubai.** Organization leading implementation of the Smart Dubai initiative.
- **Dubai Smart Government (DSG).** Technology arm of Dubai Government.
- **Dubai Silicon Oasis Authority (DSOA).**
- **Roads and Transport Authority (RTA).**
- **Dubai Health Authority (DHA).**
- **Dubai Electricity and Water Authority (Dewa).**
- **Dubai Tourism.**
- **Department of Economic Development.**
- **Needaa.** Dubai government security networks operator

5.11.5 IoT applications planned, in development, implemented

Dubai has ambitious plans across all three safe, smart and sustainable areas. To date, the greatest amount of activity, in terms of trials and live projects, is in the area of smart and sustainable projects. However, the city does take safety very seriously and is currently moving to an LTE-based emergency responders' system to replace existing PMR networks and support high-bandwidth video and data connectivity.⁷⁴

Smart city project area activity

⁷⁴ http://www.telecomreview.com/index.php?option=com_k2&view=item&id=2353



The range of smart city applications being trialled and launched in Dubai is rather wide. They include:

- **Public Wi-Fi.** Across various sites.
- **Smart lighting with environmental monitoring** in DSOA. The lights include motion sensors, live video transmission and sensors to capture environmental data.
- **Smart waste management** through sensor-equipped bins, trialled in DSOA.
- **Cycling** – electric bikes within DSOA.
- **Smart traffic management and smart parking.** Led by the RTA, this includes ITS, electronic toll systems and congestion management.
- **Smart metering/smart grid.** Plans for 250k smart meters to be installed by DEWA by 2018.
- **Data platform** – the Dubai Data initiative data portal, which aggregates data and provides open APIs to encourage innovation by third parties.

5.11.6 Key lessons

Dubai shows a number of key lessons:

- **Funding.** Tying smart projects to key infrastructure sites with their own funding – such as with the Expo2020 site – makes it easier to unlock capital for investment in smart infrastructure.
- **Dedicated testbeds.** Through setting up the DSOA as a dedicated test site for smart applications, the city is able to trial projects in a controlled environment before full-scale roll-outs.
- **Communication.** From the beginning Dubai realised the important of communicating the benefits of its initiatives to its citizens and getting feedback from them, for example through its ‘happiness meter’.

5.11.7 Machina research view

- Dubai is a very wealthy city with very wealthy citizens⁷⁵. Despite its challenging climate and physical environment its problems are about over-development rather than

⁷⁵ Only 15% of Dubai’s population are citizens.

underdevelopment. Its plans for the IoT in smart city deployments are about improving comfort and convenience rather than as a solution to intractable problems.

- Its achievements show what can be done in a city-state where the resources of local and central government are overlapping, and where project champions do not have to contend with the difficulties of negotiating a path across the electoral cycle.
- The emphasis is very much on instrumentation of processes; despite the aspiration to be the happiest city in the world there has been relatively little attempt to engage citizens in co-creation of smart city applications. This could be an area where Dubai could learn from other developed country cities, in particular in Europe, though it remains to be seen how well this would fit with the overall culture of public participation.

5.12 Jeddah

5.12.1 Key figures

- Population: 3.9 million (2014).⁷⁶
- GDP: £104.65bn (2014).
- Unemployment: 5.7% (2014).

5.12.2 Portrait

- Jeddah is the second largest city in Saudi Arabia, behind Riyadh, and has the largest port on the Red Sea.
- Jeddah is the principal gateway to both Mecca and Medina, the holiest places in Islam.

5.12.3 Smart City

- Jeddah stated its ambition to become a smart city, like other cities in Saudi Arabia such as Makkah and Yanbu Industrial City. City leaders are backing development projects worth SR250bn to bring about Jeddah smart city, including improving its transport infrastructure, the city's attractiveness as a tourist destination plus encourage the adoption of smart energy technologies.
- Jeddah's smart city ambitions remain at the planning stage. But given the momentum elsewhere in the country for the introduction of smart city technologies the city's plans should quickly commence.

5.12.4 Key bodies

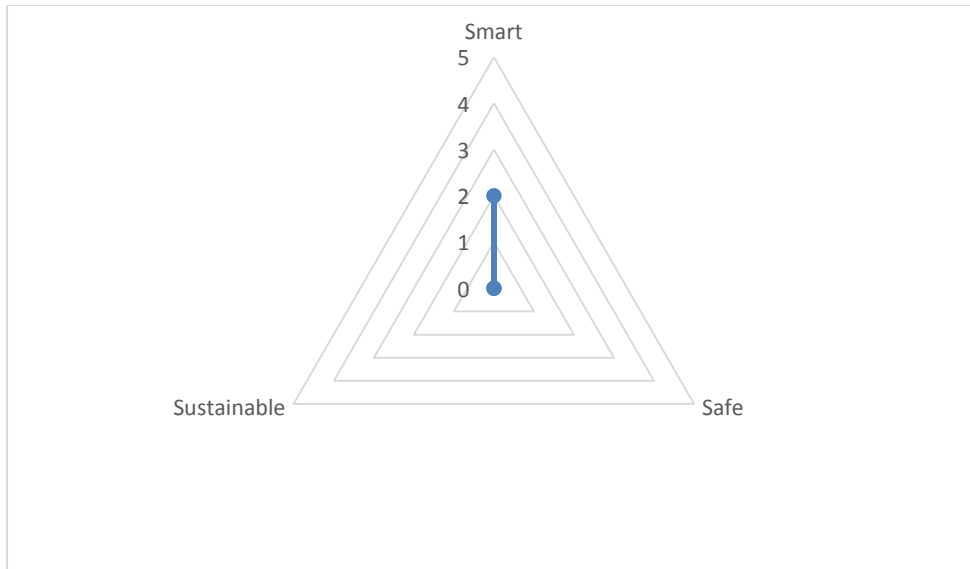
- **Jeddah Municipal Council** delivers public services on behalf of the people and of Jeddah.
- **The Jeddah Chamber of Commerce & Industry** serving the needs of the national economy and business community.

⁷⁶ <http://www.building.co.uk/global-city-focus-jeddah/5078203.article>

5.12.5 IoT applications planned, in development, implemented

Jeddah's smart city plans currently look to address their infrastructure needs including expanding the availability of broadband across the municipality.

Smart city project area activity



Jeddah has prioritised the development of its digital infrastructure and the expansion of broadband connectivity across the municipality.

- Nokia, along with mobile and data service operator Zain KSA, are working on implementing technologies (including IoT and cloud) to improve municipal services in the city by connecting and managing devices in vehicles and homes. Zain plans to deploy its mobile broadband network in 2018 and expand the utilization of small cells and Wi-Fi to ensure continuous connectivity throughout the city.
- Jeddah Municipality launched a contest in October 2015 themed “Toward a smart city” in partnership with the Computing and IT department of King Abdul Aziz University. The objective of the competition was to encourage the development of smart city applications concerning governance, security, the environment or improving people’s lives. There have been no further announcements at the time of writing.
- Major infrastructure contracts to build tunnels, bridges and roads plus drain rainwater and treat sewerage. It is unclear whether IoT solutions will be part of the projects.

5.12.6 Key lessons

- **Jeddah is not a smart city yet.** The concept of smart city in Jeddah is much broader than elsewhere and includes regeneration projects, such as improving the waterfront, the city's roads and how it copes with storms.
- **Ambitious city.** Jeddah has the appetite to develop its digital infrastructure. By exploiting the potential offered for broadband connectivity, cloud and IoT will improve services for citizens.

“The idea of our strategy is to have the basic components (for Jeddah) to become Smart. One of the outcomes of our strategy is to create examples, such as a green field area and a brown field area of Jeddah, and then make them smarter. Then to work on creating smart applications and solutions in other layers as well.”

- Dr Arwa al-Aama Vice Mayor, Information Technology Affairs, Jeddah Municipality

5.12.7 Machina research view

- Jeddah's smart city strategy places infrastructure, especially connectivity, at the forefront. There are few detailed plans for smart city applications yet, and it is therefore hard to draw out lessons for others.
- There is obvious scope to use the IoT to optimise the ambitious greenfield infrastructure project, and these too could provide lessons for other cities in challenging geographical sites.
- The intention to widen citizen involvement through a public contest, and via academic institutions, may be a model for other developing-world cities where there is a strong emphasis on education but a weak culture of public participation.

5.13 Mexico City

5.13.1 Key figures

- Population: 22 million (2014).⁷⁷
- GDP per capita: USD 14,382 (2008).⁷⁸
- Unemployment: 3.7% (2008).⁷⁹

5.13.2 Portrait

- Mexico City lies at an altitude of 2,250 metres in a valley encircled by mountains – a topography that poses particular challenges in terms of managing pollution.

⁷⁷<http://www.brookings.edu/blogs/the-avenue/posts/2015/03/05-latin-americas-stagnating-global-cities-parilla-trujillo-berube>

⁷⁸http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1306291319853/CS_Mexico_City.pdf

⁷⁹<http://www.easyexpat.com/en/guides/mexico/mexico-city/work/unemployment-benefits.htm>

- There are some 5.5m cars on its roads making it one of the world's most congested cities.
- Since 2013 Mexico City has had a city-to-city trade agreement with Chicago to foster joint initiatives in trade, investment and innovation. According to the Brookings Institution, Mexico City is the Chicago area's second-largest North American trade partner, after Toronto.

5.13.3 Smart City

The devastating earthquake suffered by Mexico in 1985 has driven a lot of the city's thinking around smart cities. Specifically, the authorities want to have appropriate policies, procedures and infrastructure to cope when the next one occurs. The latest Resilience Strategy was published in September 2016 and the number one priority is to "create resilience through institutional coordination and regional strategic communication".

Mexico City has a **Climate Action Program 2014–2020** which among other things looks to establish joint responsibility between government and its citizens to achieve a low-carbon society. The city has pledged to reduce carbon emissions by 14% from municipal transport, by 9% from waste management, and by 6.4% from residential electricity and fuel consumption from 2012 to 2020.

In addition, its **Plan Verde** (Green Plan) is a 15-year initiative, which began in 2007 and has the backing of the United Nations and the World Bank. The plan aims for the city's authorities to allocate 8% of the city's annual budget to make the city more environmentally friendly.

The two main areas of focus for the city's resilience department are using data to:

- Prepare the city for floods and earthquakes
- Reduce the numbers of deaths and injuries on the city's roads, particularly pedestrians and cyclists.

The department has worked with the partners of the 100 Resilient Cities programme⁸⁰ (pioneered by the Rockefeller Foundation to help cities become more resilient to physical, social and economic challenges), ESRI, Palantir, TomTom and Uber to map the city and explore ways to improve public services.

5.13.4 Key bodies

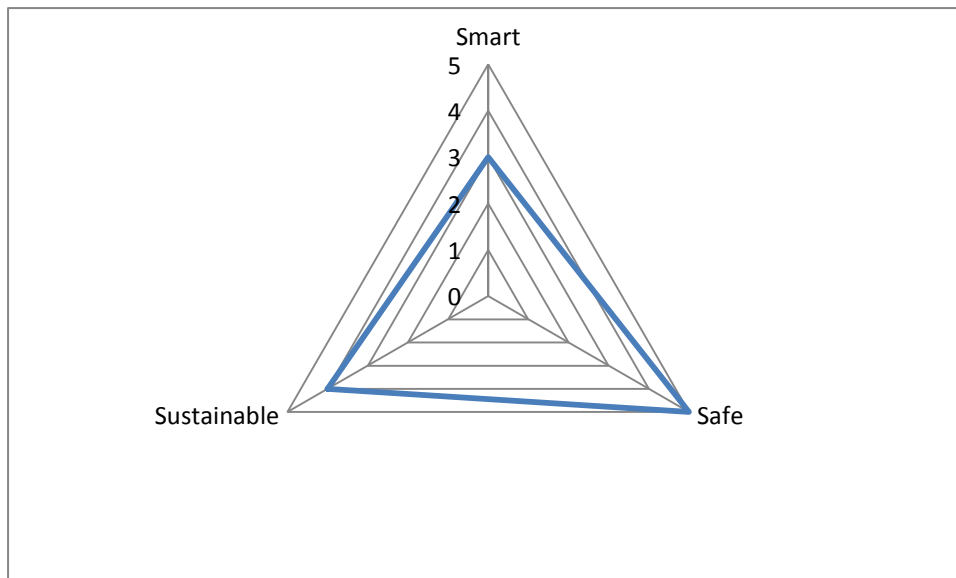
- The city's **Resilience** Department, part of Head of Government Office's responsible for defining the city's resilience strategy, facilitates and coordinates the city's data sharing activities.

5.13.5 IoT applications planned, in development, implemented

Mexico City has implemented projects across each of the smart, safe and sustainable categories, with greatest activity in the area of safety.

⁸⁰ http://www.100resilientcities.org/blog/entry/the-first-100-cities#/_Yz5jJmg%2FMSd1PWI%3D/

Smart city project area activity



Its main smart city projects include:

- **Traffic management and incident detection.** The city has over twenty thousand cameras and sensors dotted around the city which feed information into five control rooms overseen by a city-wide C4I centre (command, control, communications, computers and intelligence). Thales and telecommunications operator Telmex have implemented the solution which includes gunshot sensors, automatic number plate recognition cameras, aerial surveillance drones and emergency call points in the city's streets.
- **Smart grid.** Silver Spring Networks is implementing a smart grid project for Mexico City's Central District, which includes 140K residential and commercial customers. The project aims to reduce levels of electricity theft.
- **Cycling.** The city's bike-sharing system, ECOBICI, has been in operation since February 2010 and recorded 120,000 users in its first four years. The environment agency estimates that the system saved the city 232 tons of carbon dioxide emissions in its first three years of operation. There is a partnership in place between ECOBICI and Carrot car-sharing⁸¹, which helps to reduce traffic congestion.
- **Disaster monitoring.** Sensors dotted around the country are monitored by seismologists. When the sensors' signal is received in Mexico City alarms are sounded to hopefully give citizens enough time to get out into the streets.
- **Environmental monitoring.** Mexico City monitors pollutants in the atmosphere through a network of sensors and communicates health alerts via an app.
- **Data platform.** The city has a data platform in place through which staff can exchange information around systemic risks not only earthquakes but also air pollution. In addition, the resilience team has prioritized centralizing the disparate data sets held within the city's departments in order to analyse them to improve public policy.

⁸¹ <http://stories.newco.co/2016/02/05/carrots-cars-cut-down-mexico-city-congestion/>

5.13.6 Key lessons

- **Coalition building.** The most important lesson that Mexico City has learnt as it has rolled out its smart city projects is the need to build coalitions across departments at the beginning of projects in order to get them off the ground. This is because individual departments are typically highly focused on their day to day requirements and will not allocate resources for new, strategic projects otherwise.

"In addition to having goals and indicators around specific programmes, you need to make them cross departmental goals. And make those goals a mix of quantitative measures and also around tangible behavioural change."

– Arnoldo Matus Kramer, Chief Resilience Officer, Mexico City

5.13.7 Machina research view

- With the constant threat of earthquakes, incomparable air pollution and traffic congestion, and a high crime rate Mexico City has many challenges and therefore many opportunities to deploy IoT solutions.
- Thus far it has largely pursued an 'anchor city' approach, with the core implementation the C4 control centre integrating CCTV and other surveillance and sensor data. But several other IoT implementations such as the environmental monitoring network and application do not appear to be integrated with this.
- The central control room implementation seems to be state-of-the-art and could potentially be a model of other cities. But this approach is often not well thought of, particularly in Europe, and the lessons may not transfer well.
- Its use of Uber and TomTom to gather data via crowd-sourcing is innovative. Mexico City has a data sharing platform for internal use but could evolve this into a more open, outward-facing open data portal.

5.14 New York City

5.14.1 Key figures

Population: 8.5 million (2015).

GDP: USD 1.5 trillion (2014).

Unemployment: 5.2% (July 2016, seasonally adjusted).

5.14.2 Portrait

- New York City is a city of global renown. Wall Street is a leading financial centre, Broadway shows are world famous and the city is the headquarters for many media, advertising and legal services firms. New York is also one of the world's most popular tourist destinations
- In 2007, Michael Bloomberg launched PlaNYC, a 25-year blueprint for managing the city's growth sustainably.
- The current mayor, Bill de Blasio, is continuing PlaNYC and has published his own document "One New York".

5.14.3 Smart City

New York plans to be the most sustainable big city in the world. Mayor Bloomberg had committed the city to reduce its carbon emissions by 80% by 2050. These plans have been continued by Bill de Blasio with, for example, all waste diverted from landfill by 2030 and a targeted reduction in the use of plastic bags.

The Mayor's Office for Technology and Innovation published Building a Smart and Equitable City in September 2015. The report outlines projects where the city's departments are using IoT to improve government services. Specific examples include smart lighting, managing traffic and waste, monitoring air and water quality, and helping police officers detect gunshots.

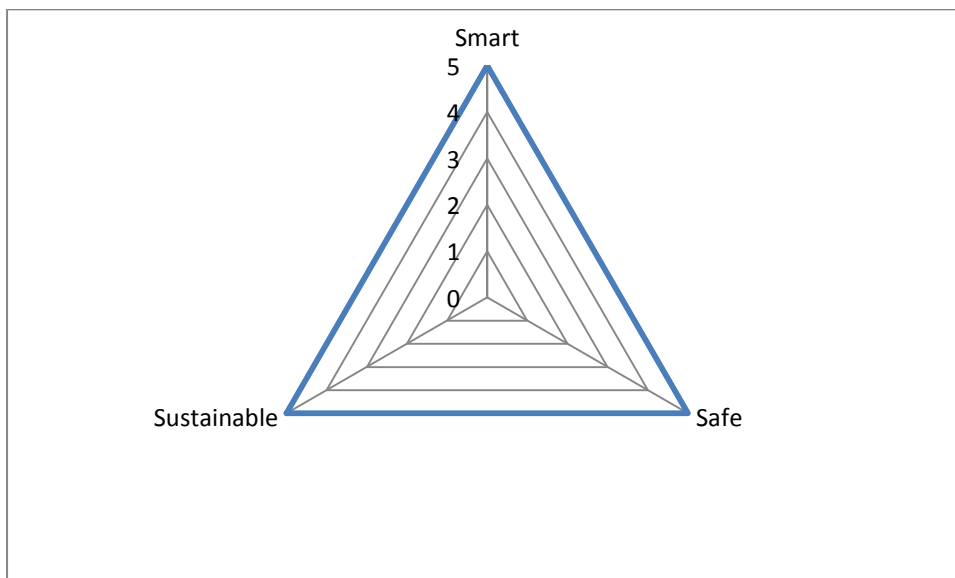
5.14.4 Key bodies

- The **Mayor's Office of Technology and Innovation** facilitates citywide coordination and collaboration on technology issues. In particular, it advises agencies on innovation and interacts with the wider New York City technology ecosystem.
- **New York City Council** is the law making body of the City of New York. The council has 51 members representing the 51 council districts of the city's five boroughs. The city council monitors the performance of the city agencies.

5.14.5 IoT applications planned, in development, implemented

New York City has launched a large number of projects across all three of the smart, sustainable and safety categories.

Smart city project area activity



Its smart projects include:

- **Incident detection** – The city operates real time gunshot detection in high crime areas. The acoustic gunshot-monitoring equipment can pinpoint gunshots within seconds. An operator reviews the audio to confirm the noise before alerting NYPD officers on their smartphones or tablets.

- **Energy management** – the city is retrofitting its public buildings, schools and public housing to increase their energy efficiency as part of the initiative ‘One City, Built to Last: Transforming New York City’s Buildings for A Low-Carbon Future’.
- **LinkNYC kiosks**, which were introduced across Manhattan in 2016. These converted old phone booths into hotspots with gigabit Wi-Fi Internet speeds, mobile apps and services.
- Building on the smart kiosk concept, Google's sister company Sidewalk Labs is looking to install kiosks that monitor bike and pedestrian traffic, air quality plus street noise.
- The city’s **DataBridge program** looks to integrate all the data collected from 40 different agencies into a single analytical platform.

The city had also run a smart parking trial. However, the transport department has decided not to take this forward as the sensors didn’t work effectively in the extreme temperatures that the city experiences while the skyscrapers hindered connectivity.

In terms of technology the city has invested in:

- **smart grids** – to improve energy transmission and help residents manage their consumption.
- **monitoring levels of air and water pollution.**
- **smart mobility** – for example, traffic lights and buses on three routes are linked via sensors so that the lights stay or turn green as the bus approaches.
- **a smart waste program** – where the sanitation department is alerted to empty bins when needed.

In addition, the New York City Economic Development Corporation (NYCEDC), in partnership with New Lab and Grand Central Tech, announced in February 2016 that it will invest up to \$7.2 million and build two Urban Technology Growth Hubs in Manhattan and Brooklyn to encourage the creation of clean energy and smart city technologies.

5.14.6 Key lessons

The following key lessons have been important for NYC:

- **Coordination** – in particular the need to coordinate between departments, private sector suppliers and academia in order to establish best practice. Need to have a flexible solution in order to avoid vendor lock in.
- **Not to forget the human element.** Although the gunshot monitoring project was about the technology the critical component turned out to be training officers in interpreting the audio correctly.
- **Focus.** The city’s innovation department is small and so has concentrated on areas where it can have the most impact. These areas include providing best practice guidelines to departments that are further ahead with their deployments and helping smaller departments to gain the most from IoT related projects.
- **Transparency.** Need to have transparency in order to embed best practice.

5.14.7 Machina research view

- New York is already a much more sustainable, low carbon and safer city than many other US cities. It is wealthy, densely populated, with a rich technologically sophisticated infrastructure legacy and well developed municipal and academic institutions. It has been successful in involving the latter in some of its projects.

- There is a vigorous start-up culture, with many non-municipal projects aimed at using IoT to make cities better⁸².
- It ought to be a solutions factory, but many of its implementations are still very much work in progress, with few documented evaluations.
- Its decentralized, facilitating approach to support operational departments in their own projects may be a template for other developed world-cities to follow.
- The lessons it has learned about the human and training barriers to adoption of smart city solutions will also be transferrable and valuable. Its Databridge⁸³ shared platform goes beyond merely hosting or curating datasets, to include ingestion and analytics, as well as training for operational departments.
- Its focus on making sure that innovations are thoroughly communicated via mainstream media to citizens is another lesson that other cities should learn.

5.15 Paris

5.15.1 Key figures

- Population: 2.2 million (2013).⁸⁴
- GDP per capita: EUR53,639 (Île-de-France, 2013).⁸⁵
- Unemployment: 7.7% (2016).⁸⁶

5.15.2 Portrait

- Paris is the capital city of France and its largest by population.
- It has a diverse economy comprising trade, retail, fashion, business services, finance, manufacturing, tourism and transportation.
- It is also an important site for science and technology research.

5.15.3 Smart City

In 2015 the Mairie de Paris set out its vision for Paris as a 'smart and sustainable' city through its Digital City 2015–2020 master plan.

The city views smart city infrastructure and applications as an important facilitator to address challenges it faces in the areas of:

- **Energy supply** – including reducing consumption and increasing use of renewables.
- **Environmental protection** – including reducing emissions.
- **Managing growth in urbanisation.**
- **Improving transportation and logistics.**
- **Providing better water and waste management.**
- **Improving food security.**
- **Improving resilience.**

⁸² For just one example see <http://dontflush.me/>

⁸³ <http://www1.nyc.gov/site/analytics/initiatives/citywide-data-sharing.page>

⁸⁴ <http://www.insee.fr/fr/ppp/bases-de-donnees/recensement/populations-legales/departement.asp?dep=75>

⁸⁵ <http://www.bdm.insee.fr/bdm2/affichageSeries?idbank=001739121&codeGroupe=1656>

⁸⁶ <http://www.bdm.insee.fr/bdm2/affichageSeries?idbank=001515940&codeGroupe=713>

- **Increasing digital inclusion.**

Guiding principles for the city as it looks to create an 'open', 'connected' and 'ingenious' city through the use of smart city applications include:

- **Efficiency** – helping to deliver public services more cost effectively.
- **Open data** – to enable innovation and to facilitate more open government, underpinned by an Open Data policy.
- **Citizen participation** – in particular through use of data gathered from the public.

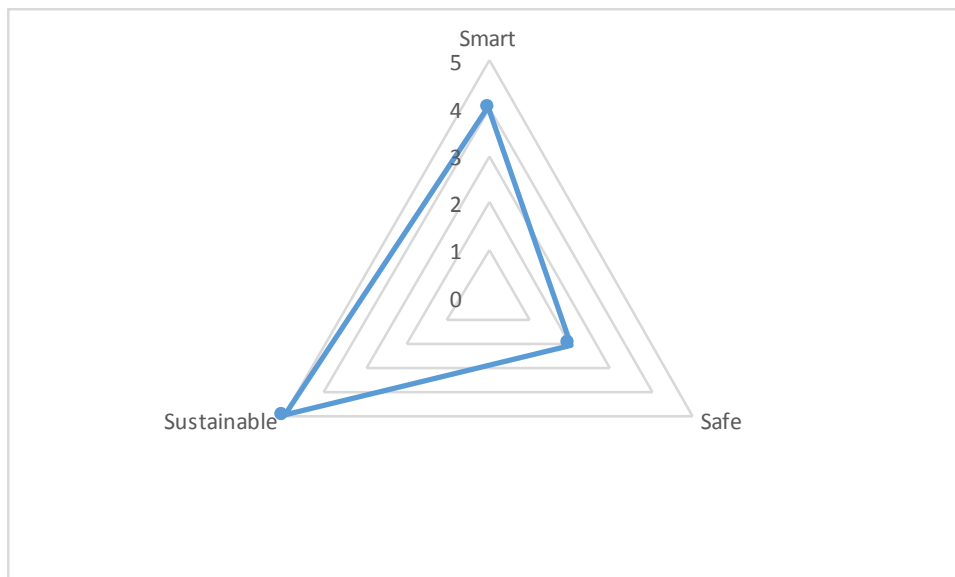
5.15.4 Key bodies

- The **Conseil de Paris** is the governing body of Paris, made up of members drawn from each of Paris's twenty arrondissements.
- It is led by the **Mairie de Paris** which runs a dedicated Smart City Office.

5.15.5 IoT applications planned, in development, implemented

Paris is most advanced in the areas of smart and sustainable, with several live projects and many trials underway.

Smart city project area activity



Paris's main smart city projects include:

- **Cycling** with an existing Vélib 17,000-strong bike sharing scheme.
- **Transportation** through a long-standing network of traffic measurement road sensors and its new 3000-strong Autolib' electric car-sharing scheme.
- **Parking sensors and reservation system** to be trialled around taxi ranks, delivery spots and high-demand parking places.
- **Public Wi-Fi** – rolling out 2000 Wi-Fi hotspots across Paris.
- **CCTV.**

- **Connected street furniture** for example through introducing digital signage at bus shelters.
- **Environmental monitoring** through rolling out an urban sensor network across the city.
- **Open data platform** – with an open data database and platform for the distribution of data and apps.
- **Smart energy, water and waste management** through rolling out remote monitoring and management of networks to be combined with data analytics.

5.15.6 Key lessons

Key lessons from Paris include:

- **Leading with visible schemes.** The city's Vélib bike sharing scheme is well-known, helping create visibility and public support for less visible smart city activities (such as environmental monitoring). Its connected street furniture programme is likely to build on that.
- **Open data.** Putting in place an open data platform is enabling Paris to encourage innovation and co-creation from third parties that is likely to benefit it in the future.
- **Dedicated leadership.** The creation of a 'Smart City Office' provides a focus for its smart city activities and enables it to communicate clear goals and objectives.

5.15.7 Machina research view

- Paris has a very well developed and documented vision for becoming a smart city. In addition to the plan described above there is also an unofficial, more 'blue-sky' vision going out to 2050 which sees Paris as a world ecological capital⁸⁷.
- The highly centralised approach taken by the city is counterbalanced by the 20 arrondissements, each of which have their own Mairie (city council), and some of which have their own smart city plans.
- Paris is a 'beta city' with many separate initiatives running in parallel and limited integration between them.
- The primary focus is on sustainability, with a particular emphasis on transport. This reflects the pressure on the transport network, which carries a heavy burden because rising property values force working Parisians to move to the suburbs.
- Paris has less engagement with EU funding and projects, and with other cities, than some of its European counterparts.

5.16 Pune

5.16.1 Key figures

- Population: 3.1 million (2011).⁸⁸
- GDP: \$48 billion (2015).⁸⁹

⁸⁷ <http://vincent.callebaut.org/page1-img-parissmartcity2050.html>

⁸⁸ <https://in.finance.yahoo.com/photos/the-top-15-indian-cities-by-gdp-1348807591-slideshow/the-top-15-indian-cities-by-gdp-photo-1348807056.html>

⁸⁹ <https://www.quora.com/What-is-the-current-GDP-for-Pune>

- Unemployment: 10.8% (2010).

5.16.2 Portrait

- The second largest city in the state of Maharashtra, behind Mumbai.
- Pune's main industries include manufacturing automobiles and engineering. In addition, the city has a burgeoning IT sector with more than 400 start-ups and is one of the top 5 FDI destinations in India.
- A spokesperson for PUNE Smart City Development Corporation Limited (PSCDCL) commented that Pune wants to be considered 'the torchbearer in innovation, research and technology in India which provides plenty of employment opportunities for its citizens'.

5.16.3 Smart City

Pune's Smart City Proposal was chosen in January 2016 to be one of the first twenty cities to be selected for priority financing under Prime Minister Narendra Modi's plan to develop 100 Smart Cities in the country. The state government priorities are to develop Pune as a smart city for education and information technology

Pune has established a smart cities budget of over USD450 million for the next five years. Sources of funding include a grant from the government of USD 150 million, land sales (contributing USD150 million) with the balance being funded through convergence from other government schemes.

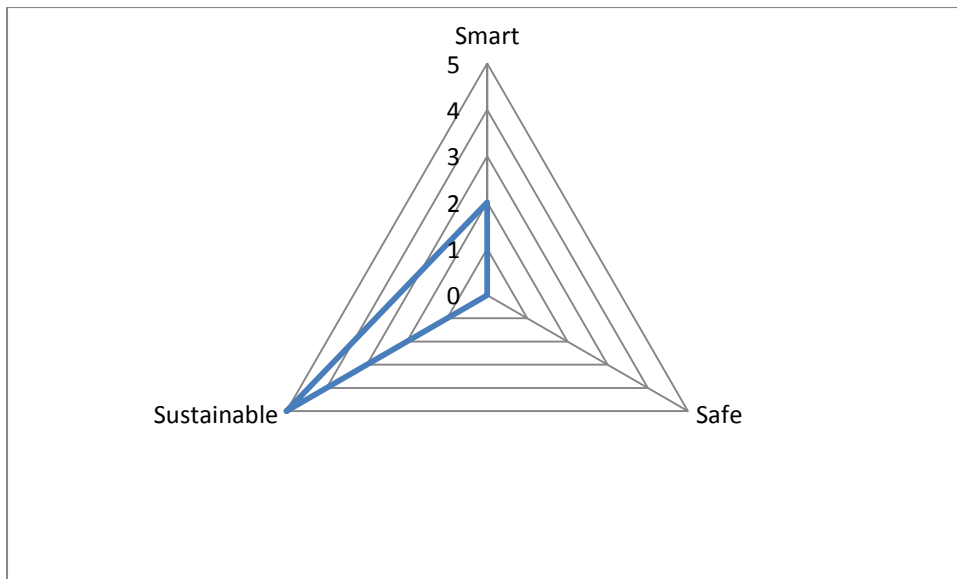
5.16.4 Key bodies

- **Pune Municipal Corporation (PMC).**
- **PUNE Smart City Development Corporation Limited (PSCDCL)** – a Special Purpose Vehicle (SPV) established by PMC for the purpose of implementing the Smart City proposal. It is fully owned by the Government with equal shareholding from the Government of Maharashtra and the Pune Municipal Corporation (PMC).

5.16.5 IoT applications planned, in development, implemented

It is early days for Pune's smart city projects which so far are mostly concerned with sustainability.

Smart city project area activity



Pune's main smart city activities comprise:

- **Transportation and fleet management.** Pune has launched a command and control centre for tracking public buses and waste vehicles as well as receiving data from all the city's departments on which it carries out analytics. The data collected by the command and control centre is also being used to model demand for public transport. Maintenance of the buses will also be improved by utilisation of sensors and analytics to monitor the health of the bus fleet. A mobile app enables citizens to also track the location of buses.
- **Cycling.** Public transport will be further improved by a bicycle sharing scheme and a mobility integration card (**Mi Card**) which enables residents to pay for parking and metro tickets.
- **Open data platform.** The city already has established an open API policy framework to ensure that data can be shared across platforms.
- **Lighting.** Pune's street lights are being switched over to energy efficient LEDs.
- **Smart meters.** Domestic water meters will mean that residents will get accurate bills.

5.16.6 Key lessons

Key lessons from Pune include:

- **Communication.** The voice of citizens is the single most important input for creation of city plans; focus on identifying the true needs and views of the citizens.
- **Partner ecosystem.** It's critical to have an eco-system of partners to create the best possible plan. Companies, organizations, educational institutions, citizen groups, NGOs, government bodies, media, industry bodies, elected representatives and many others came together to create such an eco-system in Pune.
- **Investment and expertise.** Upfront investment and expenditure in the creation of the city's smart strategy and plan is key. Cities should ensure the best-in-class experts, consultants etc. are involved from the start. City administrators must think about low-cost, high-impact smart ICT solutions to improve quality of infrastructure.
- **Project evaluation criteria.** Cost-effectiveness, feasibility, impact on services levels and inclusiveness are the four most important factors while designing solutions.
- **Diversify funding sources.** Don't over rely on government as source of funds. Cities must push to become self-sustainable and not dependent on State or Central funds to develop city infrastructure. Sources such as land monetization, PPP, multilateral and bilateral debt should all be actively pursued.
- **Project feasibility.** Administrators must focus on feasibility and impact and not lose touch with on-the-ground realities. This ensures that plans and proposals made are not just paper plans but real, effective solutions that will actually solve the city's problems.
- **Avoid technology lock-in.** Use open standards based technology at the software and hardware level, wherever it is available and applicable to avoid lock-in to a specific vendor technology and hardware.

"One thing which surprised me a lot and is worth mentioning is the way the citizens of Pune participated and provided their opinion in the overall challenge. Their responses and desire to improve the city has overwhelmed me."

– Kunal Kumar, Municipal Commissioner, Pune municipal corporation

5.16.7 Machina research view

- Pune is part of the ambitious Indian Smart Cities Mission, backed by very strong support from central government, via a competition, that sees smart cities as key to economic transformation and solving social and environmental issues.⁹⁰
- There is a very broad definition of 'smart' in Pune's programs. For example, it includes the retrofitting of foot paths on roads that don't have them, as part of its 'smart mobility' strategy. This is actually quite smart as a low-cost but essential way to promote sustainability in personal transport, but it does not fall within anyone's definition of an IoT project.
- As with other cities in the national program there is a Special Purpose Vehicle to run the smart city, and a very strong emphasis on citizen engagement; this is one of the assessment criteria for the funding competition.
- Participation in the national program gives Pune access to shared resources, notably the Ministry of Urban Development's SmartNet Portal⁹¹, designed to enable cities to share ideas

⁹⁰ <http://smartcities.gov.in/>

⁹¹ <http://www.thehindubusinessline.com/news/national/centre-to-launch-portal-for-smart-cities/article8710119.ece>

and source solutions for implementation. This includes benchmarked cases and best practice documentations, model RFP documents, financial models and business cases, land monetisation ideas, SPV structures and innovative practices, risk mitigation techniques and an Open Source Software Library to showcase apps developed and will highlight new source software developed by mission cities during the execution phase.

5.17 San Francisco

5.17.1 Key figures

- Population: 864,000 (2015).
- GDP per capita GDP: USD78,844 (2013).
- Unemployment: 3.7% (July 2016).

5.17.2 Portrait

- San Francisco is the 4th biggest city in California and the second most densely populated city in the United States.
- The city's main industries include financial services, tourism and technology.

5.17.3 Smart City

San Francisco's stated aim with its smart city projects is to improve the lives of its citizens with a particular focus on sustainability and tapping into the expertise in of the technology firms in Silicon Valley.

Its smart city activities are focused on providing:

- resilience to natural disasters.
- building environmental sustainability.
- improving the transport infrastructure.

Responsibility for resilience falls under the Office of the City Administrator under the leadership of Patrick Otellini, Chief Resilience Officer. The department looks to provide systems and structures that will increase the City's resilience overall (especially to earthquakes).

The SFMTA's Office of Innovation is currently seeking a new leader after Tim Papandreou announced in July 2016 that he will be leaving the agency for Google X. Papandreou was the point of contact with Google and other regarding creating policies concerning driverless cars.

The Start-up in Residence program is run by the Mayor's Office for Innovation and is for startups and City departments aims to explore innovative approaches to civic issues, and to prototype and test solutions over four months. Its projects include tracking neighbourhood air quality, sending emergency notifications, and providing airport navigation for the blind and visually impaired.

5.17.4 Key bodies

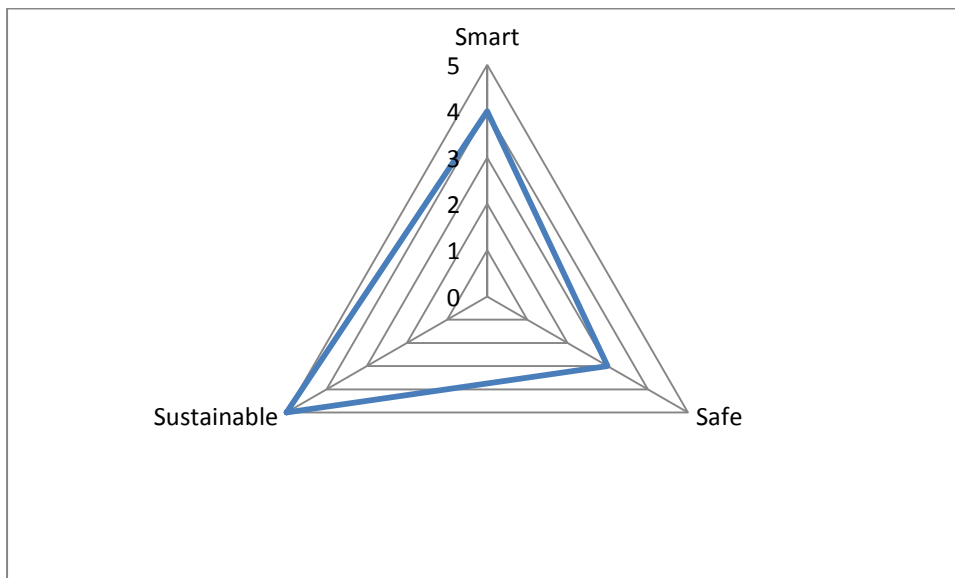
- **Mayor's Office for Innovation's** – role is to champion new ideas, tools and approaches in city government.

- **Office of Resilience & Recovery** – responsible for implementing Resilient San Francisco, directly overseeing the City’s 30-year Earthquake Safety Implementation Program and managing the City’s Lifelines Council.

5.17.5 IoT applications planned, in development, implemented

San Francisco has implemented projects across all three smart, safe and sustainable categories.

Smart city project area activity



San Francisco’s smart city activities include:

- **Open data platform.** The Department of Technology (DT) manages a single internet site for the San Francisco’s public data called **DataSF**. This open data platform contains all the city’s non-confidential datasets.
- **Waste management.** San Francisco has a zero waste program; the goal is to be sending nothing to landfill by 2020. Contributing to the zero waste program is the Recycle Where? website. Using Open Source software and an open data model the site provides information about recycling, reuse, and proper disposal options for residents and businesses. The initiative is a collaboration amongst local governmental agencies including San Francisco Department of the Environment, StopWaste.Org (Alameda County Waste Management Authority), Contra Costa County, City of San Jose and the City of Palo Alto.
- **Smart lighting.** The LED Conversion Project was launched in 2014 with the new smart LED lamps equipped with wireless capabilities that will enable the authorities to monitor and control the lights remotely. There are approximately 43,000 streetlights in the City and County of San Francisco
- **Smart meters.** In 2015 the California Association of Water Agencies expressed concern that there was an increasing risk of water theft with water tanks at schools, fire hydrants, lakes and rivers on public land being targeted. In response the San Francisco Public Utilities Commission (SFPUC) installed automated Smart Meters for residents and in public building that alert the agency to abnormal water use in the district.
- **Transportation.** The SFMTA launched **SFpark** in April 2011 to manage the availability of on-street parking, reduce congestion and greenhouse gas emissions. The smart parking meters

change their prices depending on the time of day, their location and the day of the week. But the programme's future is uncertain. Eighty percent of SFpark's funding came from the US Department of Transportation and the remainder from SFMTA. The trial came to an end in 2014 and since then the city has been trying to devise a plan for continuing the project without relying on federal funding.

- **NextBus**, owned by Cubic Corporation is a mobile app that uses data from SFMTA to tell passengers when the next bus will arrive.

The San Francisco Municipal Transportation Agency (SFMTA) plans, designs, builds, operates, regulates, and maintains San Francisco's transportation network. Over the past six years the Transit-Only Lane Enforcement (TOLE) pilot has successfully helped reduce double parking and people stopping in transit lanes. It uses both cameras and staff to look for and cite rule breakers. TOLE will now become a permanent fixture.

"Members of the public need to be involved in projects as early as possible; not just in focus groups when project has already been designed but right at the beginning. And keep them involved throughout the project."

- Rayna Gordon-Hellman of the San Francisco Mayor's Innovation Office

5.17.6 Key lessons

- **Align smart city projects with political priorities.** San Francisco's Mayor, Ed Lee, has prioritized housing, police and homelessness. The technology projects run by the Mayor's Office for Innovation need to apply to one of these themes.
- **Contracts.** Ensure contracts are strong by not getting bogged down with legal considerations when designing projects and contracts. Have prequalified suppliers to call upon to maintain a project's momentum.
- **Departments will innovate in isolation.** San Francisco's Public Health and Transport departments are beginning to establish their own innovation teams. The Mayor's Innovation team are optimistic that members of these teams will not be too entrenched in their departments and will look to engage with others.

5.17.7 Machina research view

- San Francisco is in many ways an advanced smart city with many achievements to which it can point. It has also, perhaps wisely, repositioned some of its well-established intelligent transportation projects as smart city initiatives.
- But it has taken a somewhat fragmented approach and has found co-ordination and integration of its initiatives a challenge. It could learn from others about how to build trust and communications between departments.
- It suffers from electoral cycle issues; the priorities that shaped the outgoing mayor's administration have not entirely carried over into the new regime. Although there is a strong desire to involve start-ups in solving the city's economic and social issues (especially homelessness and the lack of affordable housing) there is also a growing perception that the

population attracted by the technology industry is part of the problem as well as part of the solution.⁹² The mayor has to tread carefully between these two strands.

- San Francisco can teach other cities much about how to conduct large-scale pilots, of which SFPark may be the best example in the world. But it also needs to learn more about how to convert pilots, even successful ones, into operational deployments.

5.18 Sao Paulo

5.18.1 Key figures

- Population: 11.9 million (2014).
- GDP at PPP: USD430 billion (2014).⁹³
- Unemployment: 8.3% (Jan 2016).

5.18.2 Portrait

- São Paulo is Brazil's largest city and is Brazil's commercial hub.
- ICT, oil and natural gas, the green economy, aeronautics and automotive are its important segments.

5.18.3 Smart City

Although São Paulo's Mayor, Fernando Haddad, has prioritised smart city projects since coming in to office in 2013 however only a handful of smart city projects have been launched to date. These have largely focused on the areas of security and street lighting.

5.18.4 Key bodies

- **Invest SP** and **SP Business** are the promotion agencies for the state of São Paulo and the City Hall and the key contact points for international firms looking to offer smart city solutions.

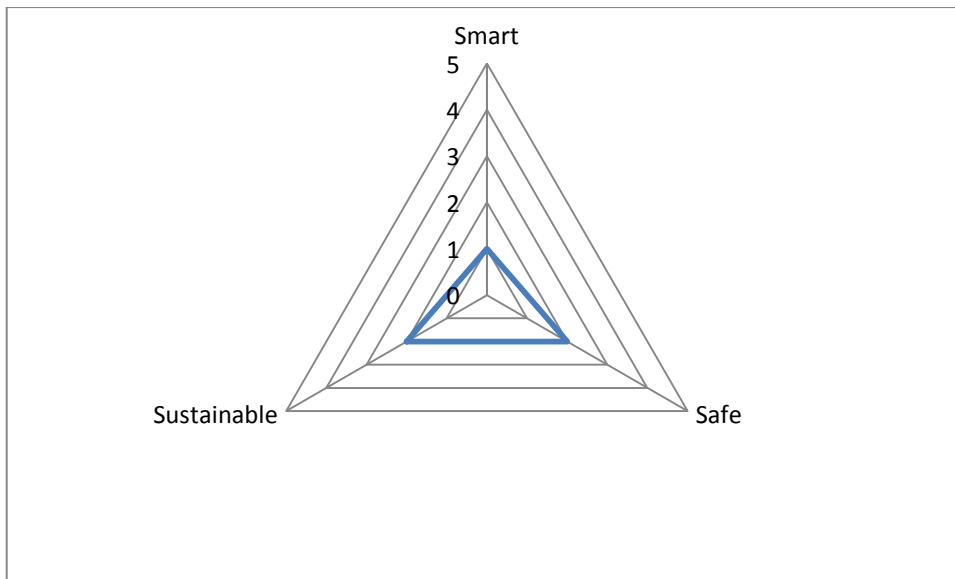
5.18.5 IoT applications planned, in development, implemented

São Paulo has had an emergency alerting system (concerning natural disasters or civil defence) for over thirty years which connects to all the large departments. However, beyond this, only a handful of smart city related projects are taking place in São Paulo.

Smart city project area activity

⁹² See "Throwing Rocks at the Google Bus" described here: <https://www.ft.com/content/a4e7cda0-deda-11e5-b072-006d8d362ba3>

⁹³ <http://www.en.investe.sp.gov.br/why-sao-paulo/diversified-economy/>



The main smart city projects in São Paulo to date, comprise:

- **Lighting.** The city's Smart Streetlighting project involves replacing existing streetlamps with 600K LED lights. Currently the poles do not include sensors. The firm chosen to deliver street lighting will be able to add sensors to the poles with revenues generated from the data collected shared between the supplier and City Hall.
- **Environmental monitoring.** The Environment department monitors air pollution with sensors automatically feeding in to a database with the results published online.
- **Public Wi-Fi.** The city has introduced free Wifi in public places with the authorities hoping that this will provide marketing and merchandising opportunities.
- **Big data.** The São Paulo state's Public Security Department launched a big data solution in 2014 that integrates phone calls coming in to the police's contact centres, the video cameras spread across the city and the policemen patrolling the streets. The project was developed in partnership with Microsoft.

To monitor progress São Paulo has established an analytical laboratory for urban mobility (MobiLab), staffed by transport professionals as well as computer and data scientists.

In addition, since 2014 a pilot project has been underway to transform the city of Águas de São Pedro, a small municipality with about 3,000 citizens located 187 kilometres from São Paulo, into a digital-driven smart city. The pilot is a partnership between the city government and Telefónica Vivo and Huawei. Its aim is to modernize the telecommunications network and deploy smart solutions in the areas of health, education, security and tourism.

5.18.6 Key lessons

Three areas which São Paulo are currently trying to address include:

- **Interdepartmental co-ordination.** Lack of a central body with the ability to work across departments to get programmes established.
- **Data sharing.** Lack of a data sharing culture among departments.
- **Communication.** More work needs to be done so that citizens and departments become aware of the potential of IoT and smart city technologies to improve their lives.

5.18.7 Machina research view

- São Paulo has elements of ‘beta city’ and of ‘anchor city’. It is at a very early stage of its development. It has pressing problems in terms of safety (crime), sustainability (especially traffic and air quality) and the ability of its infrastructure to cope. Like Mexico City, it values a centralised control centre for security and safety applications. Nevertheless, there has been little impact so far on some of these problems.
- Its focus on future business models is welcome and positive, but its lack of an integrated approach means that it may have missed several tricks – for example, in deploying LED streetlights without also connecting sensors.
- As in other cities it has made a smart district an element of its strategy, but has chosen a relatively affluent spa-dominated tourist resort as the site for this. This bears an element of risk, especially in such a highly politicised environment. São Paulo could learn from other cities about how to position IoT as a tool for the regeneration of districts in greater need.

“São Paulo is on the cusp of increasing Smart City activity (more multinationals are approaching the authorities). The challenge is getting the attention of departments who are more concerned with day to day activities and making the solutions compelling for the citizens.”

- Marco Aurelio de Barcelos Silva Director, São Paulo Business (São Paulo City Hall).

5.19 Shanghai

5.19.1 Key figures⁹⁴

- Population: 24 million (2013).
- GDP per capita: RMB90,100 (2013).
- Unemployment: 4.2% (2013).

5.19.2 Portrait

- Shanghai, lying on China’s east coast, is the largest city in the world by population.
- It is a major global centre for finance, manufacturing, retail, transportation and shipping; it hosts the world’s busiest container port.

⁹⁴ <http://www.chinaknowledge.com/CityInfo/City.aspx?Region=Coastal&City=Shanghai>

- Two of the major challenges for the city are reducing its extremely high level of air pollution and managing growing transport congestion.
- It has a well-developed public transport system.

5.19.3 Smart City

Shanghai sees the three primary objectives for its smart city projects to be to:

- **improve people's livelihood** e.g. in terms of education and healthcare.
- **expand smart management of the city** e.g. traffic and environment.
- help make **city management more efficient**.

The city emphasizes its conceptualisation of a smart city as being in terms of improving the life outcomes of the city's inhabitants.

It views mobile network connectivity (3G and 4G), cloud computing and big data as the key underlying technologies, which it expects will be provided by traditional telcos (e.g. China Telecom, China Unicom, China Mobile) while applications will be provided by vertical operators and platform owners (e.g. Ali, Tencent).

The city is currently pursuing an approach of developing separate, vertically-integrated platforms for each application. However, in future it envisages moving to a horizontal platform to operate across vertical applications in order to facilitate easier data sharing.

For Shanghai, the three biggest challenges in making a success of its smart city projects have been:

- achieving open data sharing.
- overcoming the digital divide with unconnected people.
- Changing society and culture.

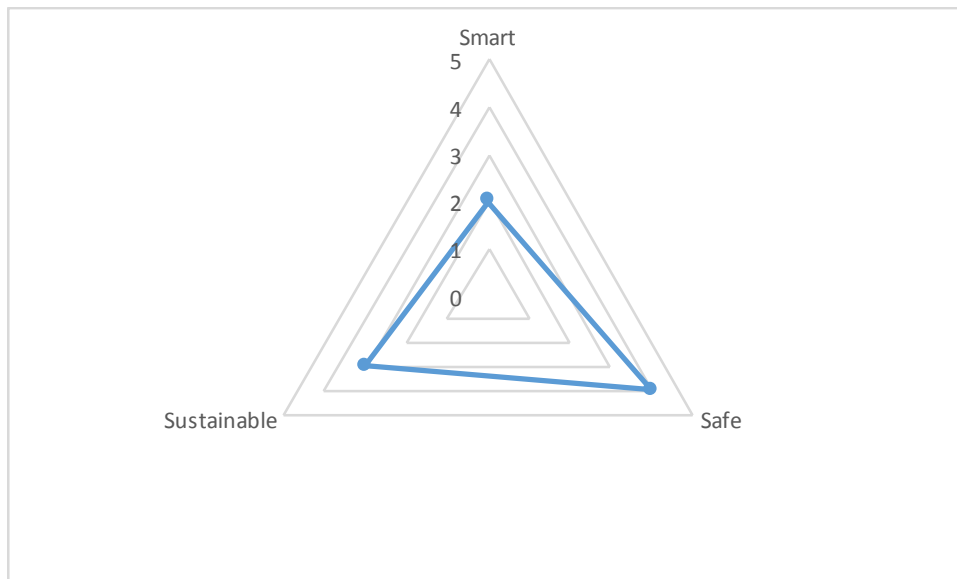
5.19.4 Key bodies

- **Shanghai Municipal Government.**

5.19.5 IoT applications planned, in development, implemented

Shanghai has launched smart city projects across smart, sustainable and safe areas. However, it is most advanced in terms of safe projects with, in particular, extensive connected CCTV infrastructure in place.

Smart city project area activity



The city's primary, already deployed, smart city applications include:

- **connected CCTV** – extensively deployed.
- **smart waste management** – management and use of electronic tags.
- **smart healthcare, including aged care** – use of cloud services and apps.

Shanghai is currently trialling a number of other smart city application applications, including:

- smart lighting – live pilot.
- intelligent transport systems (ITS) including electronic toll collection – several live pilots.
- environmental monitoring – early stage of trials.
- smart parking – some live pilots in business areas.
- big data – analysis of data gathered by government departments.

5.19.6 Key lessons

Three of the key lessons identified by Shanghai from work on its smart city projects to date are:

- **Selection.** The need to follow a careful process to evaluate and select potential projects.
- **Implementation.** The need to have an overall plan with guides for step-by-step implementation of projects combined with appropriate monitoring to ensure plans are being followed.
- **Communication.** The need to communicate effectively with the population to ensure that citizens know about and understand projects in order to ensure adoption of services.

5.19.7 Machina research view

- Shanghai has pursued an 'anchor' approach, in that it has prioritized applications around safety and surveillance, based on CCTV. But its highly connectivity-centric focus could perhaps be considered a 'platform' approach, albeit one that is mainly about network infrastructure rather than a common application platform.

- This goes some way to explaining the key role that Shanghai allocates to telecoms network operators in its strategy. Applications are to be created and provided by separate vertical-specific IT companies.
- The city has taken an unusually municipality-centric approach, with a limited role for other local or national bodies. There is less emphasis on creating an ecosystem or introducing new kinds of players and innovative business models in comparison to some of the other cities in this report.
- Shanghai could learn from others about how to build relationships and communications between organizational silos. It could also develop a more open approach to data-sharing and co-creation.

5.20 Singapore

5.20.1 Key figures

- Population: 5.6 million (2015).⁹⁵
- GDP per capita: USD 51,855 (2015).⁹⁶
- Unemployment rate: 2.1% (2016).⁹⁷

5.20.2 Portrait

- Singapore is both a city and a state situated in south east Asia.
- The city is a hub for commerce, finance and transport hub and for the last ten years has led the World Bank's rankings for ease of doing business.

5.20.3 Smart City

Singapore is one of the world's leading smart cities with many IoT-related applications underpinning a number of government services. In November 2014, the prime minister launched the Smart Nation Initiative. The city has put smart city technologies at the heart of improving the lives of its citizens.

Singapore aims to become a 'living laboratory' for smart urban technologies across areas including:

- water and transport systems.
- green buildings.
- clean energy.
- city management.

One of its stated objectives is to nurture firms with expertise in these segments who then export their products and services.

⁹⁵ <http://thinkingcities.com/hong-kong-faces-challenge-from-singapore-in-smart-city-planning/>

⁹⁶ <http://www.tradingeconomics.com/singapore/gdp-per-capita>

⁹⁷ <http://www.tradingeconomics.com/singapore/unemployment-rate>

In 2016, Singapore's government allocated USD13.9bn for R&D which includes its investment in smart city technologies.

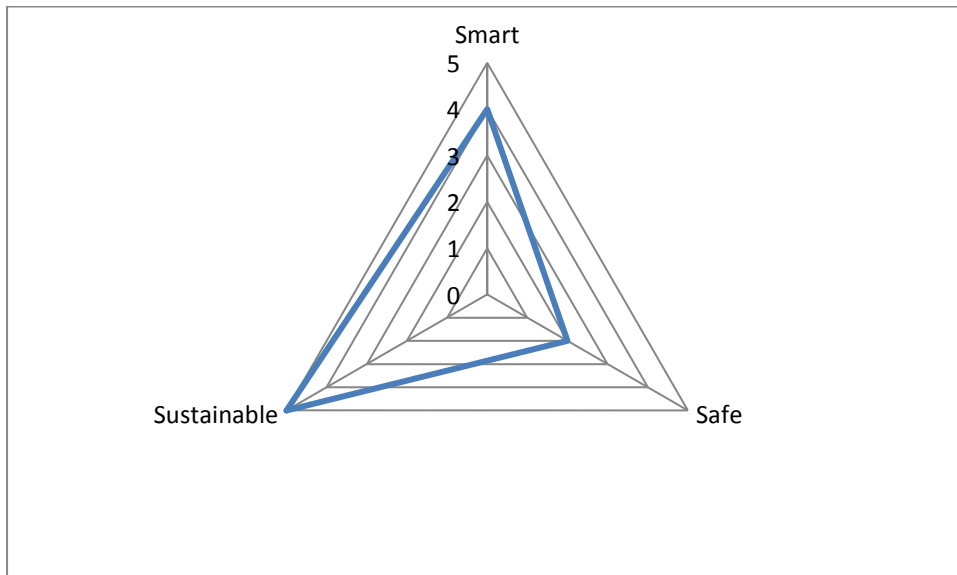
5.20.4 Key bodies

- **Singapore's Economic Development Board.**
- **Info-communications Media Development Authority (IMDA).**
- **Land Transport Authority.**

5.20.5 IoT applications planned, in development, implemented

The number of projects relating to the sustainability and smart categories reflect Singapore's ambition not only to be a smart city but also to export its expertise overseas.

Smart city project area activity



Singapore's main smart city applications include:

- **Behavioural monitoring.** The city has deployed sensor networks that are used to detect whether people are smoking in unauthorized zones or have thrown litter from a tower block. They are amongst the most advanced in the world.
- **Smart parking.** Its sensor networks are also used to help residents find parking spaces using the Park&Go smartphone app, which was launched in 2015.
- **Smart lighting and CCTV.** Singapore's lamp posts are networked, solar powered and equipped with cameras and sensors that can provide video feeds and other data.
- **Intelligent Transport System.** The city's Smart Mobility 2030 initiative involves deploying an Intelligent Transport Systems over the next 15 years. Aiding the planning process is the MATSim (Multi-Agent Transport Simulation) which simulates individuals' travel patterns throughout the day. MATSim has been developed by the Future Cities Laboratory of the Singapore-ETH Centre (a partnership between the Swiss Federal Institute of Technology Zurich and the National Research Foundation (NRF)). The day to day experience of travelling across

Singapore has also been improved by a collaboration between the Land Transport Authority, SMRT Corporation Ltd (SMRT), StarHub and IBM which has applied data analytics to improve the performance of the public transport system.

- **Journey planner app.** For individual commuters there is the MyTransport Journey Planner app, launched in 2014 by the LTA, which provides real-time travel information to help commuters know bus arrival times and how crowded the buses are.
- **Driverless cars.** In 2014, the Government convened a high-level Committee for Autonomous Road Transport in 2014 to run driverless cars tests.
- **3D Mapping.** The city has modelled the entire country in 3D to create a smart map. It is looking to produce a Virtual Singapore app which contains climate and demographic, geometric, geospatial and topology information with real-time data feeding in to the platform. The project will provide the foundations for overlaying IoT related applications.
- **Waste management.** Volunteers have attached tracking devices to pieces of rubbish in order to understand where the trash ends up and improve how waste is managed in the city.
- **Water management.** The city has installed a Smart Water Grid, an island-wide wireless sensor network that minimizes water leaks working with a real-time Silt Imagery Detection System that automatically monitors the smooth running of waterways. It also has deployed an autonomous robotic platform, the New Smart Water Assessment Network (NUSwan), that conducts real-time water quality monitoring. This was launched by Singapore's (NUS) Environmental Research Institute and the Tropical Marine Science Institute.

During 2013 and 2014, Singapore piloted a platform called the **Safe City Test Bed** where government agencies collaborated with industry consortia to build and test solutions for urban management and safety and security. The four consortia were from (1) Accenture, (2) AGT International, (3) Airbus Defence and Space working with NCS and (4) NEC Asia Pacific. Each consortium utilised data and video analytics, simulation, modelling and machine learning to develop urban management solutions. The Ministry of Home Affairs stated in 2014 the exercise has improved their operations and reduce resource requirements.

In 2015, the IMDA launched its Smart Nation Platform (SNP) operating system. This will enable public agencies to access, manage and share sensor data. The Jurong Lake District in western Singapore is being used as a test-bed for the technologies underpinning this Smart Nation Platform.

5.20.6 Key lessons

The city has been prepared to experiment to see which solutions work best and encourage local suppliers to find buyers across the globe.

5.20.7 Machina research view

- Singapore is in many ways the most advanced 'platform city', even though the platform itself is relatively new. It has done a great deal with IoT technology even as it has worked towards its platform.
- It already has mature intelligent transport applications (some of which are siloed) a public transport system that is the envy of the world, and a centrally planned and directed affordable housing policy that exemplifies the benefits of public-private partnership⁹⁸.

⁹⁸ See <http://www.citylab.com/housing/2015/03/how-singapore-fixed-its-affordable-housing-problem/388451/>

- The city faces sustainability and resilience issues, especially around water. Sustainability is not a feel-good or virtue-signalling issue here but an absolute necessity to enable the city to survive and prosper.
- Its apparently low scores on the metrics used in this study do not entirely reflect its achievements; for example, it scores low on 'safe' because of few IoT initiatives but must surely be one of the safest cities in the world⁹⁹.
- It is unburdened with an awkward electoral cycle, and as a city-state has no tensions between national and city priorities. There is a high tolerance for government control and surveillance that would be hard to replicate elsewhere – the sensor networks to detect unauthorised smoking and litter-throwing are very Singaporean.
- Its Safe City Test Bed manages to involve several vendors and thereby avoid the risks of lock-in. However, despite its wish to become a 'living lab' it does not appear to understand the concept in the way that it is used in other cities, particularly in Europe. There is little emphasis on action research or attempt to engage citizens in the co-creation of initiatives and applications. In this respect at least there is still potential to learn from other cities.

5.21 Tokyo

5.21.1 Key figures

- Population: 13.5 million (2015).¹⁰⁰
- GDP (PPP): USD1,617bn (2014).¹⁰¹
- Unemployment: 3.6% (2009).¹⁰²

5.21.2 Portrait

- Tokyo is the capital city of Japan and one of the world's most expensive cities in which to live.
- It is a major international finance hub with also electronics, transport equipment, optical goods and publishing important contributors to the city's economy.
- The city will host the 2020 Summer Olympics and Paralympics.

5.21.3 Smart City

Energy security is an investment priority after the city experienced black outs in the aftermath of the earthquake/ tsunami of 2011. For example, the authorities are implementing energy resiliency projects in Nihonbashi and Hibiya districts, and are implementing localised power grids for use in emergencies.

Despite being an advanced city with respect to infrastructure Tokyo is yet to implement large deployments of IoT applications.

⁹⁹ In the Economist safe city index it comes second in its region, just behind Tokyo <http://safecities.economist.com/report/safe-cities-index-white-paper/>.

¹⁰⁰ <http://www.metro.tokyo.jp/ENGLISH/ABOUT/HISTORY/history03.htm>

¹⁰¹ <https://www.brookings.edu/research/global-metro-monitor/>

¹⁰² <http://stats-japan.com/t/kiji/11187>

Panasonic opened an eco-village outside the city centre in 2014. Fujisawa Smart Town is a zero carbon emission village focuses on using renewable energy and the smart home.

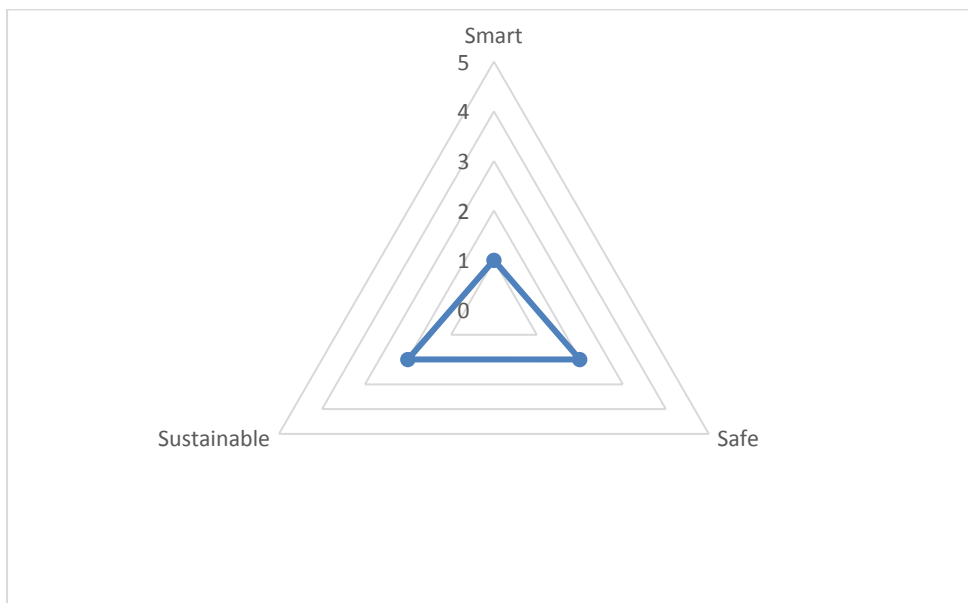
5.21.4 Key bodies

- **Tokyo Metropolitan Government** administers the 23 Special Wards of Tokyo.

5.21.5 IoT applications planned, in development, implemented

Tokyo has mainly launched smart city projects in the area of sustainability.

Smart city project area activity



Tokyo's smart city activities include:

- **Smart Meters.** Tokyo Electric Power Company (TEPCO) is installing over 27 million smart meters to track domestic and commercial demand.
- **Cycling.** There is a bike sharing scheme across the city.
- **Waste management.** There are plans to introduce smart bins to optimise waste collection.
- **Public Wi-Fi** is available across the city.
- **Wayfinding.** Multi lingual digital signage and wayfinding apps will be introduced in the city in the run up to the Olympics.
- **Disaster monitoring.** The city has installed earthquake tracking sensors.

Tokyo relies on third-parties to create mobile apps for tourists.

In addition, the city authorities hope that by the Olympics in 2020 the city will be utilising renewable energy and be perceived as a **Smart Energy City**. The Tokyo Metropolitan Government introduced solar-powered battery charging stations in 2015.

5.21.6 Key lessons

Despite being a global city with world class transport infrastructure authorities have not prioritised the deployment of IoT applications.

This will change in the near future with The City Vision document outlining plans to have a world class entrepreneurial city with Tokyo Metropolitan Government supporting SMEs by providing support for technologies in growing industries such as robotics and helping those businesses expand overseas.

5.21.7 Machina research view

- Tokyo is, like a number of other cities in this study, at a very early stage in its smart city journey. The most important drivers for the city are: the impending Tokyo Olympics¹⁰³, which will put a strain on infrastructure but will also provide many opportunities to deploy showcase urban applications; the need for resilience in the face of natural and man-made disasters; and the national 'Smart Japan ICT Strategy', which includes an explicit but not very detailed commitment to smart cities and towns as agents of transformation¹⁰⁴.
- Tokyo's transport system and urban environment is unusual, and faces specific problems as a result of its planning policies which have resulted in a peculiarly low-rise, low-density urban form.¹⁰⁵ This makes housing expensive and journeys to work long. Smart urban mobility and intelligent transport systems are a high priority.
- Tokyo has many advantages as it starts its route to becoming a smart city. It has an abundance of high-bandwidth connectivity, a plethora of universities and research institutes, a growing start-up community, and a population with high levels of ICT skills and willingness to engage with new services. On the other hand, it is falling behind in terms of Open Data, dropping from 19th to 31st place (out of 122) in a global index of data openness.¹⁰⁶
- It is in a good position to learn from other smart cities around the world, and should pay particular attention to the value of a living labs approach, large-scale pilots, and about which IoT applications are working elsewhere.

5.22 Vienna

5.22.1 Key figures

- Population: 1.8 million (2014).
- Gross regional product per capita: EUR47.2k (2013).
- Unemployment: 11.6% (2014, registered rate).

5.22.2 Portrait

- Capital city of Austria.
- Is consistently highly ranked on quality of life indices and home to two UNESCO World Heritage Sites.

¹⁰³ http://www.eu-japan.eu/sites/default/files/publications/docs/smart2020tokyo_final.pdf

¹⁰⁴ <http://www.soumu.go.jp/english/gisb/>

¹⁰⁵ <http://marketurbanism.com/2012/06/28/tokyos-surprising-lack-of-density/>

¹⁰⁶ <http://index.okfn.org/place/japan/>

- Economy is dominated by services followed by industry and commerce. Strong in research & development. Germany is a major trading partner.

5.22.3 Smart City

The city developed its 'Smart City Wien Framework Strategy' over 2011–2014. This sets out three high-level objectives through to 2050:

- radical resource preservation e.g. significant reduction of CO2 emissions.
- high and socially balanced quality of living.
- development and productive use of innovations and new technologies.

Vienna's smart city activities comprise three main strands:

- **Individual IoT projects** that are co-ordinated or implemented by the city administration.
- **Digitale Agenda Wien.** A citizen platform for gathering and sharing ideas for digital apps.
- **DigitalCity.Wien.** A knowledge-sharing and networking forum run by TINA Vienna for Viennese start-ups. Founded in September 2014.

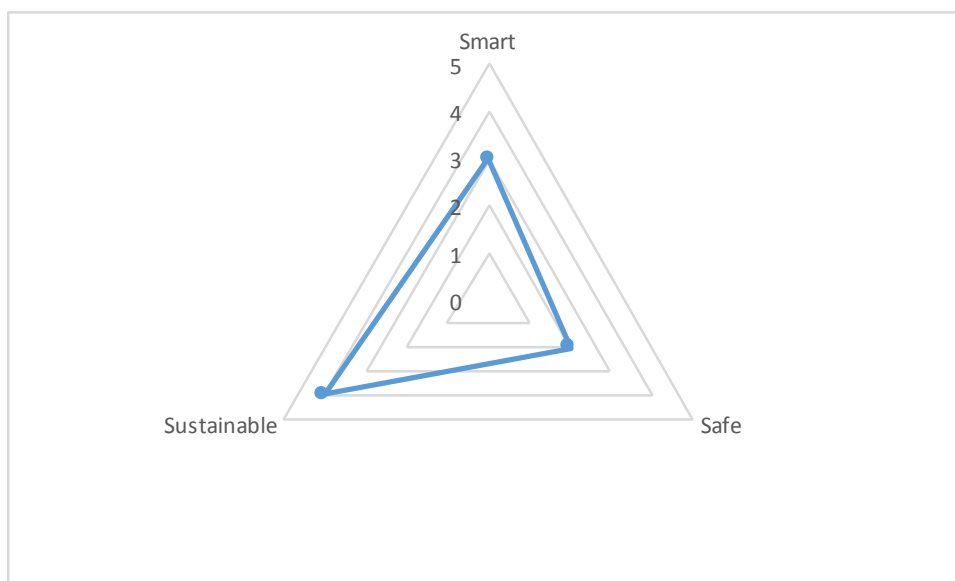
5.22.4 Key bodies

- **Vienna City Administration.**
- **Smart City Wien Agentur (Smart City Vienna Agency),** which co-ordinates smart city projects in the city. Part of TINA Vienna and owned by Vienna City (through Wien Holding).
- **DigitalCity.Wien.** Organisation launched in 2014 responsible for promoting Vienna as a digital hotspot.

5.22.5 IoT applications planned, in development, implemented

Vienna has launched projects across all three of the smart, sustainable and safety categories, with the greatest level of activity in the area of sustainability.

Smart city project area activity



Its major smart city projects typically embody a range of different 'smart' elements. They include:

- **Transform+.** A research project, launched in 2013, looking to identify ways to deliver CO2 reduction through better energy management, environmental monitoring and intelligent mobility services. Led by the Austrian Institute for Spatial Planning and the City of Vienna Urban Development and Planning department.
- **Smart Verteilerkreis.** Launched in 2015 and running to 2020 this project is implementing smart mobility solutions in Vienna's Verteilerkreis district. It is run by ASFINAG (Austrian roads and streets company) with input from TU Vienna, Wiener Stadtwerke and Vienna Business Agency.
- **Skopje Urban Transport.** Aiming to deliver improved road operations and maintenance, including through an automated traffic management system. Led by TINA International.
- **Aspern.mobil.** A long-term development project running to 2028 covering some 20k new buildings in this lakeside district. This 'urban development lab' includes a backbone of IoT, big data and learning from this data to make recommendations. It is run in collaboration with the ASCR agency.

"Putting in place the right organisational structure is critical to the success of smart city projects."

– Pamela Mühlmann,
Senior Expert, Smart
City Wien Agency

Other projects including its **Citybike Vienna** scheme and **Sterne**, a renewable energy project.

The city tracks progress on individual projects through its SMART.MONITOR project, run by the Urban Development and Planning department. It has had discussion regarding implementing a single smart city platform, in particular in relation to electric vehicle-charging infrastructure but to date does not have a single platform in place.

5.22.6 Key lessons

In the period since finalisation of the Smart City Wien Framework Strategy, Smart City Wien Agentur has identified the following lessons:

- **Strategy.** The City has found it critical to have an overall strategic plan in order to select and design individual projects.
- **Implementation.** Even with a high-level plan, implementing smart city projects has been challenging especially when refurbishing existing infrastructure.
- **Champions.** While not specific to smart city projects, there's a need for both political will and internal champions for projects to get off the ground.
- **Project vs. organisational structures.** Because of their technological components, smart city projects cut across departments which can create issues around departmental silos. The city of Vienna found a successful solution to this was to establish cross-department project teams to work on individual projects to break down department silos.
- **Innovation vs. safety.** Many city departments tend, understandably, towards the tried and tested with infrastructure projects. To combat this, it's necessary to incentivise innovation and adopting innovative ideas from outside the organisation.
- **Communication.** To ensure they are used and accepted, it's important to communicate effectively with citizens about what smart city projects are intended to do and how they can benefit from them. In addition, the Digital Agenda Wien site project helps collect ideas from the public for new applications.

5.22.7 Machina research view

- Vienna is an exemplary 'beta city'. Although it is operating a large number of pilots across a wide range of urban domains there is nothing chaotic about its process. Instead it has an orderly evaluation strategy through its Smart Monitor project.
- It has considered the possibility of swapping tracks to become a 'platform city' but has not yet made any firm commitment to do this.
- It shines in its ability to co-ordinate across different departments and entities, its engagement of citizens and academic researchers, and its evaluation processes.
- It is not particularly engaged with other national or EU programs, with other cities or with private sector partners, and could learn from others in this respect. There may also be more scope to involve start-ups in creating innovative applications and making use of open data.

5.23 Wuxi

5.23.1 Key figures¹⁰⁷

- Population: 6 million (2013).
- GDP per capita: RMB124,600 (2013).
- Unemployment: 2.1% (2013).

5.23.2 Portrait

- Wuxi, in Jiangsu Province, China is a rapidly industrialising city lying in the Yangtze River Delta, west of Shanghai.
- Its existing strengths in manufacturing and textiles have, in recent decades, been supplemented by growth in its high-tech sector, facilitated by the creation of several new industrial parks.
- Tourism is also an important sector for the city.

5.23.3 Smart City

In 2009, the Wuxi city administration, in partnership with Siemens, created an IoT innovation centre of as part of which it built a sensor network demonstration area. It subsequently participated in the smart cities programme that was launched, in 2012, across China. In 2014, the city was selected by the IEEE to be part of its smart city initiative.

As discussed in more detail below, third-party reports suggest that there has been some tension between stakeholders as smart city projects have been rolled out in Wuxi around differing approaches to data protection and open data platforms.

Wuxi's three-year smart city plan, covering 2014–16, focuses on the areas:

- Transportation.
- environmental protection.
- medical treatment.

¹⁰⁷ <http://www.chinaknowledge.com/CityInfo/City.aspx?Region=Coastal&City=Wuxi>

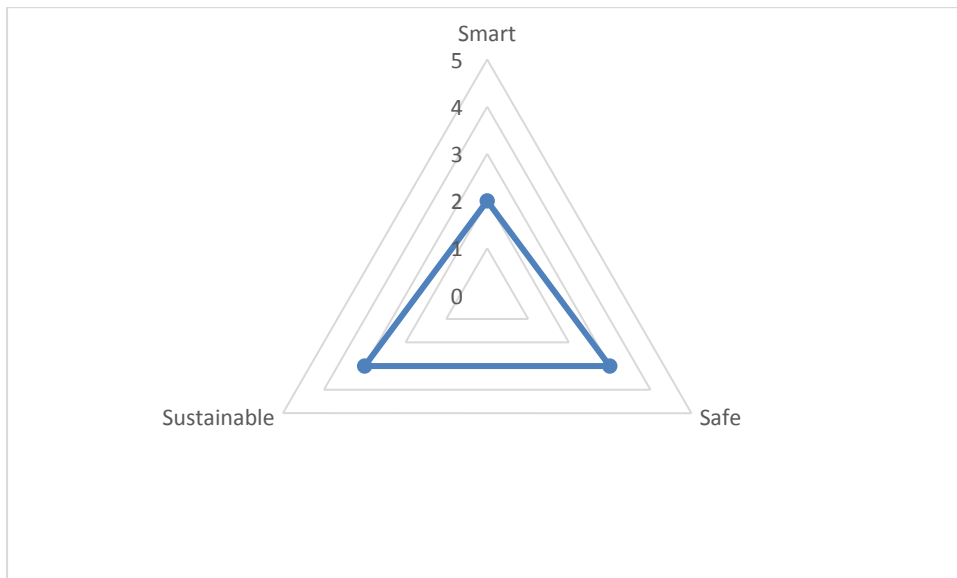
5.23.4 Key bodies

- **Wuxi City Municipal Government.**

5.23.5 IoT applications planned, in development, implemented

Wuxi is trialling or has launched projects across all three of the smart, sustainable and safe category areas.

Smart city project area activity



Its existing full-scale deployments include:

- public Wi-Fi.
- transportation – road traffic management.

Significant trial projects include:

- **environmental monitoring** – including of Lake Tai's water quality as well as sewage and air quality.
- **transportation** – including bus tracking, smart parking, bridge and tunnel monitoring.
- **healthcare** – tracking and monitoring of hospital medical supplies, remote health monitoring and electronic health records.
- **city apps** – communication of public information through WeChat and others.

5.23.6 Key lessons

Data openness vs. security.

The city administration is reported as favouring a centralised approach to data gathering. This has apparently led to some tensions between departments and third-parties which would like to access greater amounts of this data in order to develop new services. There is a need for improved data governance processes – in particular a need to specify what use data will be put to in advance of being able to experiment with data sets. The absence of these processes may be having some impact on the city's ability to innovate in the use of data.

These issues both highlight the need to establish, in advance, appropriate systems and data protection policies to balance effective data privacy and security with innovation - issues which Wuxi is currently working to resolve. Effective policies should enable data to be shared more easily both within city administrations as well as with third-parties and so enable more rapid service development in the future.

5.23.7 Machina research view

- Wuxi is clearly deeply engaged with the underlying technology for the IoT smart city, but has made less progress with the 'soft side' – the culture, management and institutions that enable a city to make the most of the technology.
- This is despite the involvement of a non-Chinese vendor partner which ought to have been able to share lessons from other cities around the world, and its engagement with the IEEE smart cities programs.
- Wuxi is one of the few cities in our study that has made extensive use of a free public internet service – WeChat – to deliver information and services to citizens. This is an 'easy win' for a smart city (although it seems to have been more widely adopted by smaller towns¹⁰⁸) at an early stage and deserves further attention.
- There is potential for Wuxi to learn from others about the role of data sharing within the city, the value of Open Data in promoting innovation from third parties, the methodology of living labs and co-creation, and the mechanism whereby citizens can be more closely involved in the definition and use of smart city applications.

¹⁰⁸ <https://www.civicplus.com/blog/seven-ways-local-government-can-use-social-media>

6 Conclusions and recommendations

Machina Research makes the following conclusions and recommendations.

6.1 Cities need to put in place rules, policies, and governance to ensure that they get the most benefit from data assets.

- There is widespread recognition of the value of data as a new resource; but it only has value if permissions and safeguards are in place that allow it to be used. Cities already have access to data about their citizens, and the IoT will give them more. The basis on which this was provided, and the uses to which it may be put, is often not clear to those citizens.
- Sharing data between departments, and with third party developers and private sector vendors and service providers, raises new issues; obtaining synergies by combining data sets inevitably goes beyond the purpose for which the data was originally provided. Private sector organisations and web-based companies which provide ‘free’ services in return for data mining may be able to hide behind the terms to which users agreed in a long and complex EULA but public bodies will find this more difficult. This has clearly been an issue for Wuxi, one of the cities included in our research.
- City authorities need to be transparent in what they are doing, at the same time as defining rules, practices and business models which encourage data sharing, third party contribution, and appropriate monetization.
- A fully ‘open’ data policy does not suit all cities or all entities within a city. Some cities are willing to make all of their data available, for free, to organizations or companies who might be able to make more innovative uses or to monetize it in ways that are not open to the city, for a variety of reasons including governance and skills. New York’s Databridge takes this one step further in providing analytics and training as well as hosting of data sets.
- Other cities see their data as a valuable asset for which they can reasonably expect to receive payment. Some smaller authorities cannot afford to make data available for free, because of the costs of formatting, cleaning and hosting that data. The Offene Data Berlin open data portal¹⁰⁹, Copenhagen’s City Data Exchange¹¹⁰ and the OneTransport¹¹¹ initiative in the UK, all of which address the monetization of data resources, may provide models to follow.
- Whichever business model is followed, it should go without saying that urban data portals should be configured to support real time data and provide clean data in standard formats.

¹⁰⁹ <https://daten.berlin.de/>

¹¹⁰ <https://www.citydataexchange.com>

¹¹¹ <http://onetransport.uk.net/>

6.2 Coordination of smart initiatives across different departments requires forethought and leadership.

- The most impressive visions for smart cities include synergies and integration between applications and data sets. This is difficult technically, because neither the hardware nor the software which support isolated applications were designed with such synergies in mind. It is difficult organisationally too.
- Specific departments have their own targets and KPIs which, at best, these applications are designed to achieve. Budgets sit within departments rather than across them. In San Francisco the operational departments have created their own innovation labs.
- In general, smart city initiatives are the province of innovation teams, strategy teams or specific organisations. The city's CIO and ICT functions, which are involved in maintaining and operating day-to-day municipal systems including internal IT, payroll, etc., are not often involved. However, there are some notable exceptions, such as the City of Westminster local authority within Greater London, where the CIO is behind and even driving the smart city strategy or some aspects of it.
- One solution to this problem, adopted by the city of Vienna, is to have smart initiatives run by cross-departmental teams with the explicit aim of breaking down departmental silos.
- An alternative approach, developed in Berlin, is to have a separate agency (here the Smart City Berlin Network, a working group initiated by Berlin Partner for Business and Technology and TSB (Technology Foundation Berlin)) which co-ordinates activities across the many different stakeholders.
- New York has taken yet another approach, with a small innovation department providing a support role to operational departments.

'In a decentralised city like Berlin it's really important to have an organisation like Smart City Berlin Network to co-ordinate activity between the many different stakeholders.'

– Britta Havemann, Policy Advisor Smart City, Berlin Senate Department for Economics, Technology and Research.

6.3 Vendors and city authorities need to make the benefits of smart city initiatives visible to the citizens.

- Some of the most sensible and practical initiatives, which are capable of delivering ROI quickly, can be invisible. Smart lighting is a case in point. It may save 60% or even 80% of the city's energy costs for lighting, but while this saving is visible to the city's finance managers it is invisible to the citizens. At best they can expect a saving on municipal taxes, but these are affected by many other factors, and the saving is not likely to be apparent in the final bill.

- This means that some of the more ‘gimmicky’ features like street lighting which can be coordinated with after-dark traffic flows or CCTV cameras are more important than they might first appear, because citizens are likely to see them.
- The extent to which this is necessary depends on the political context and the administrative arrangements; democratic politicians facing elections are more dependent on this than professional city managers. But it needs to be taken into account in planning the mix of applications and the features that they support.
- In democratically governed cities city managers and solution providers will need to take the electoral cycle into account when making plans. New politicians may question the decisions of their predecessors, have different priorities, or just need to be brought up to speed on the city’s journey towards smartness. The apparent pause in Barcelona’s smart city developments, may be an example of this¹¹²; by contrast, Bristol’s special purpose vehicle Bristol is Open allowed smart city projects to survive the election defeat of the charismatic independent city mayor in May 2016. New York’s focus on ensuring that positive developments are communicated to citizens via mass media is exemplary.
- Several of the cities in our study have made much of their citizen platforms, which not only pushes data out or publishes information but also allow citizens to co-create and suggest ideas for smart city applications. Vienna’s Digitale Agenda Wien is a good example of this; so is Bogota’s ViveLab.

‘[The] three key things are to make sure use cases are well articulated, make sure IoT investments can be tied to savings [and to] engage with the press to get the word out.’

Lindsey-Paige McCloy, Senior Product Manager, R&D, NYC Mayor’s Office of Technology and Innovation

6.4 There is a strong need to educate city procurement departments so that they can evaluate bids more effectively and allow for new kinds of relationship.

- City purchasing processes have not been developed to support the acquisition of products and services with the characteristics inherent in smart city solutions. The latter tend to be complex, subject to frequent evolution and change, involve interworking between several suppliers, and hard to measure in terms of hard metrics.
- Standards are immature, requirements are ill-defined or evolving, and relationships may include vendor financing or pay-as-you grow business models.
- Public sector procurement is often oriented towards ensuring compliance with a ‘tick-list’ set of required features followed by a comparison of financial terms and costs. In some countries

¹¹² <http://www.sustainablecitiescollective.com/katesb/1078466/smart-city-collective-intelligence-radical-change-brewing-barcelona>

exactly this approach is required by central government and written into local government law.

- Public sector procurement is also very process-intensive, and therefore ill-suited to working with innovative small companies and start-ups. The latter rarely have the time, energy or bandwidth to engage with these processes. The ability to use alternative kinds of procurement is another argument in favour of SPVs.
- Ensuring that vendor choice delivers openness and does not lock the city into a proprietary ecosystem of partners would be a challenge for anyone; for city procurement departments with limited technical knowledge it may be a significant barrier to deployment.
- Berlin's "Innovation Showroom", described above, includes helping to inform procurement functions as one of its explicit aims.

6.5 Smart city solutions should form part of programs to revive declining cities or districts

- The US government's smart cities initiative and the associated MetroLab Network explicitly includes this as an objective. This goes some way towards explaining the USD40 million awarded to post-industrial city of Columbus, Ohio by the US Department of Transportation¹¹³.
- Smart districts, in which a number of different solutions are rolled out in a geographically defined area have been a successful deployment scenario for several cities, including Berlin's (notably in its ten "Zukunftsorte"¹¹⁴), Vienna's Vertellerkreiss district, and Barcelona's District22. In Auckland the Wynyard quarter, previously occupied by oil and petroleum tanks, is in the process of being redeveloped and shows signs of following the same course of technology-led regeneration¹¹⁵. This approach can make a strong impact while postponing questions of scalability and interworking with legacy infrastructure.
- Bringing smart city solutions within a framework of urban regeneration may also enable access to wider sources of funding directed towards urban regeneration, including specific budgets within the city, or external sources including central government and regional development finance.
- There is a temptation to use more affluent areas of the city, where infrastructure and network coverage may already be in place and where citizens are more likely to be educated, tech-savvy and enthusiastic, as the basis for 'smart districts'. This is the route taken by Sao Paulo and Delhi, as described above. In general, it is a temptation that should be resisted, because it seems to undermine the argument that making the city smart will have benefits for all.

¹¹³ <https://www.columbus.gov/smartcolumbus/>

¹¹⁴ <https://www.berlin.de/sen/wirtschaft/wirtschaft-und-technologie/technologiezentren-zukunftsorte-smart-city/zukunftsorte/artikel.109346.php>

¹¹⁵ <http://www.aucklandnz.com/ateed/media-centre/listing/new-research-highlights-aucklands-thriving-innovation-ecosystem>

6.6 The right relationship with ICT vendors is a critical success factor for cities

- For the reasons described above in Section 6.4, traditional public procurement models don't work well for smart cities. It's not easy here to define requirements, issue an RFP and evaluate bids.
- Worse, the city may be missing out on a potential source of funding for its projects. Vendors have shown themselves willing to enter into more innovative relationships, including work on proofs of concept and pilots at their own risk, direct financing of projects, and revenue or savings shares. This can be especially important where the business case for an implementation makes sense but the upfront investment cannot be paid for out of the city's own budget or through borrowing.
- The flip side of this is fear of lock-in. Smart cities are a constellation of technically complex projects. Cities may not have the expertise or bandwidth to manage them. As we have seen, several cities have involved local universities and research institutions in a quid pro quo where the academics provide expert input in return for access to a real life test bed. Examples of this include Berlin, Bogota, Bristol, and Jeddah.
- The temptation is strong, though, to seek a one-stop shop from the vendor. This provides short-term relief from concerns about integration but raises the spectre of future lock-in. This is a real and justified concern, raised to us in the course of this study by several cities including Auckland, New York, Singapore and Pune. The dangers of lock-in include a proprietary ecosystem with less choice and less price competition.
- We have been impressed by the ways in which several cities have addressed this. Notable among these are Singapore and Bristol, both of which have decided to proceed on parallel tracks with several vendors as a way of ensuring future inter-operability even in the absence of mature standards. Both have offered their vendors a deep relationship and the ability to test new technologies and services in a live environment; neither have chosen a single vendor to provide them with their central application platform.

7 Further Reading

Machina Research recommends the following further reading:

'The success of the smart city depends on interoperability, achieved through standards and layered architectures' (June, 2016)

'The internet of bicycles meets the smart city' (June, 2016)

'Momentum is building for smart city platforms' (October, 2015)

'LPWA: disruptive new networks for IOT' (November, 2015)

'Understanding the drivers behind smart cities' (October 2014)

8 About Machina Research

Machina Research is the world's leading provider of market intelligence and strategic insight on the rapidly emerging Internet of Things, Machine-to-Machine (M2M), and Big Data opportunities. We provide market intelligence and strategic insight to help our clients maximise opportunities from these rapidly emerging markets. If your company is a mobile network operator, device vendor, infrastructure vendor, service provider or potential end user in the IoT, M2M, or Big Data space, we can help.

We work in two ways:

- Our **Advisory Service** consists of a set of Research Streams covering all aspects of IoT and M2M. Subscriptions to these multi-client services comprise Reports, Research Notes, Forecasts, Strategy Briefings and Analyst Enquiry.
- Our **Custom Research and Consulting** team is available to meet your specific research requirements. This might include business case analysis, go-to-market strategies, sales support or marketing/white papers.

8.1 The Advisory Service

Machina Research's Advisory Service provides comprehensive support for any organisation interested in the Internet of Things (IoT) or Machine-to-Machine (M2M) market opportunity. The Advisory Service consists of seven Research Streams (as illustrated in the graphic below), each focused on a different aspect of IoT or M2M. They each provide a mixture of quantitative and qualitative research targeted at that specific sector and supported by leading industry analysts.

Advisory Service Research Streams [Source: Machina Research, 2016]

	IoT Strategies	Analysis of the evolution and impact of the emerging concept of the Internet of Things. Topics covered include software platforms, application development, data management, machine learning, monetisation, trusted third parties and key players in this new emerging field.
	M2M Strategies	Covering commercial and technical best practice in all aspects of the provision of connected solutions, including devices, networks and service providers. Covers topics such as new technologies, Communications Service Provider strategies, standards, value chain positioning, pricing and M&A.
	M2M & IoT Regulation	Country-by-country analysis of the regulatory issues relevant to M2M and IoT. Each country profile examines issues such as licensing, roaming (including permanent roaming), numbering, spectrum availability, and data sovereignty. Also includes analysis of overall trends.
	IoT Forecasts	Our comprehensive quantitative guide to the growth of the Internet of Things, featuring forecasts of connections, technology, traffic and revenue for 200 countries across all 58 application groups covered in our 8 'Connected' verticals: Cars, Cities, Health, Industry, Home, Business, Energy and Consumer Electronics.
	Industrial & Enterprise IoT	Examines how enterprises should prioritise and approach selecting and implementing IoT applications and solutions in various domains. Explores the potential partnerships and collaborations, enabling (data) technologies and protocols, and how enterprises can secure IoT solutions with SLAs.
	Smart Cities	Looks at smart city initiatives from the perspective of the would-be user. Provides city managers with analysis of smart cities overall, recommendations over thresholds and context for deployment of different smart city applications, best practice for implementation and case studies of deployments.
	Smarter Cars	Focuses on key issues for the evolving connected car, including analysis of operating systems, OEM strategies, new business models, alternative vehicle-related applications and new developments such as autonomous driving.

For more detail on each of the Research Streams, please see the 'Machina Research Advisory Service – Guide to Research Streams' document.

8.1.1 Reports and other published content

Our research content consists of a number of broad categories of deliverable:

- **Strategy Reports** – Extensive and in-depth reports focusing on specific key major themes in IoT and M2M.
- **Research Notes** – Shorter reports examining key issues and developments in the world of M2M and IoT.
- **Application Spotlights** – Regularly updated profiles of each M2M application. Each Application Spotlight comprises Definitions, Drivers & Barriers, Market Analysis, Forecast and Conclusions & Recommendations sections.
- **Forecasts** – Many of our Research Streams include extensive market forecasts. These are available through our online Forecast tool.
- **Research Stream-specific content** – Some of the Research Streams have specific content types, for instance the Regulatory Profiles in the IoT & M2M Regulation Research Stream.
- **Previous publications** – Clients enjoy full access to our library of past publications from the Research Stream.

Each of the Research Streams includes a varying blend of the above. For details of the specific contents of each of the Research Streams, please refer to the 'Machina Research Advisory Service – Guide to Research Streams' document.

8.1.2 Strategy Briefings

An opportunity for direct face-to-face interaction between the client and the Machina Research analysts. Typically a Strategy Briefing will involve a presentation at the client's premises on a theme agreed with the client within (or closely related to) the scope of existing research.

There are no Strategy Briefings bundled as standard with any of our Research Streams. These need to be included as separate items in the subscription.

Relevant travel costs will apply.

8.1.3 Analyst Enquiry

All clients also get direct access to our analysts in the form of enquiries about the published materials and topics with the Research Streams to which you subscribe.

You may want to request clarification on something within the report, ask for a brief update or pick our brains on any issue.

We provide clients with unlimited access to our analysts, up to a maximum of one hour per enquiry. We are happy to undertake more substantial enquiries as custom research.

8.2 Custom Research & Consulting

Machina Research's analysts have a wealth of experience in client-specific consultancy and custom research. Typical work for clients may involve custom market sizing, competitor benchmarking, advice on market entry strategy, sales support, marketing/promotional activity, white papers or due diligence. Subscription clients are eligible to purchase our custom research and consulting services at discounted daily rates.

For more information on Machina Research, visit our website at <http://machinaresearch.com>.

9 About Nokia

9.1 Enabling the human possibilities of smart cities

Technology is empowering cities to respond quickly to demographic and economic shifts. However, smarter infrastructure and applications only make a difference when it enriches our lives. Responsive, flexible technology that works for humanity is what makes smart cities "smart," creating safe, sustainable cities where technology works for people.

Nokia is uniquely positioned to help governments, communication service providers and large enterprises deliver on the promise of smart cities. Nokia's solutions are designed to help ensure the best use of urban resources and data to enable the human possibilities of smart cities.

Nokia provides the essential building blocks of a smart city:

- **City-wide connectivity**, which utilizes optimal access technologies from fixed to mobile to connect all people, devices, machines/sensors and provides administrations, businesses and citizens the high speed services they expect wherever they are.
- **City shared network** based on IP, moving from siloed networks to a converged multiservice network for greater operational efficiencies and lower costs.
- **City cloud architecture** with a virtualized, software-defined network to unleash the power of the cloud and increase flexibility to connect sites, workgroups, and applications faster and more securely.
- **City IoT platform**, which manages the city's sensors and collects, analyzes and utilizes the data through secure third party applications.
- **City applications**, which leverage an eco-system of trusted partners to offer cities a fast path to innovative applications and services.

10 Appendix: Data Annex

10.1 Data table

Figure 2 shows the consolidated scores for all of the cities studied in this report in terms of the three axes for which we have evaluated the cities' progress.

Figure 2 Cities' Smart, Safe and Sustainable scores compared

City	Smart	Safe	Sustainable
Auckland	2	2	2
Bangkok	3	3	1
Barcelona	4	4	5
Berlin	3	2	4
Bogota	3	0	3
Bristol	2	2	2
Cape Town	3	2	1
Cleveland	3	4	3
Delhi	1	1	1
Dubai	4	2	3
Jeddah	2	0	0
Mexico City	3	5	4
New York City	5	5	5
Paris	4	2	5
Pune	2	0	5
San Francisco	4	3	5
Sao Paulo	1	2	2
Shanghai	2	4	3
Singapore	4	2	5
Tokyo	1	2	2
Vienna	3	2	4
Wuxi	2	3	3