The Making of a Digital City
Pathways to Success

February 2019

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Introduction

Smart cities are a big part of our planet's future—bringing cost savings, resource efficiency, and new sources of data to city management—but to date, achieving this aspiration has been challenging.

It's not for lack of potential. Marrying data and advanced technologies to digital and wireless networks has the potential to improve the quality of urban life while reducing costs for governments, businesses and citizens. Smart cities can make material improvements to citizens' quality of life in no fewer than eight major areas, including safety, transport, healthcare and the environment (See Exhibit 1). Smart cities contribute directly to at least four of the United Nations Sustainable Development Goals (SDGs). BCG estimates that an at-scale deployment of smart technology can generate more than €350 million per year of direct and indirect value for a city of 1.5 million people.

EXHIBIT 1

Source: BCG analysis

SMART CITY APPLICATIONS SPAN EIGHT DOMAINS

So what are the main impediments? Most can be traced to a combination of scale and complexity: cities are large organisms, smart city solutions are hard to standardise, and each city has different priorities and stakeholders to manage.

Research by the GSMA and BCG for this report identifies four of the most significant hurdles as the following:

- The challenges of coordinating multiple stakeholders in a smart city ecosystem
- Value cases that don't work for one or more stakeholders[1]
- The complexities of data management, owing in part to privacy regulations and the risk of security vulnerabilities
- The lack of deployment at scale of technological solutions, which exacerbates the first three issues

Despite plenty of pilot programs, and the individual proof of concept of some specific smart city applications, this combination of hurdles has kept most initiatives from moving beyond the trial phase, limiting the overall value captured. BCG analysis suggests that only 20% of smart city solutions have been deployed beyond 10% population coverage, even in the most developed cities.

Municipal governments (together with their regional, state and national counterparts) and the private sector, including telecommunications companies, have a common interest in overcoming these roadblocks and unlocking the potential of smart cities. Doing so requires establishing a clear ambition and strategy and ensuring that all efforts are set up to scale. Smart city leaders need to design public-private value cases that work for all stakeholders and capture social benefits. Industry and government need to collaborate on platforms and ecosystems that spark innovation and achieve maximum value.

Unlocking the smart city potential is essential for the long-term well-being of city dwellers. This report presents recommendations for accelerating the digitalisation of cities. It starts with the challenges that have limited progress to date. It breaks down the specific roadblocks. Then it puts forth a strategy for moving forward that is based on the premise that, to be effective, all elements must have the ability to scale. Lastly it presents the steps that governments and industry can take to demonstrate progress in the near and medium term.

1. Value case is used here as quite a few of stakeholders value different outcomes than money and business case could thus be misinterpreted. in the 3.5 GHz band.

Big Need, Limited Progress–So Far

For the world to address some of its most pressing problems, from energy consumption to mobility to climate change, we need smarter cities. This need will only increase as the global population grows and the share of population living in urban centers increases (to 68% in 2050, according to a 2018 estimate by the UN Department of Economic and Social Affairs). Four of the SDGs cannot be achieved without the application of digital technologies, especially in cities. For example, good health and well-being require smart management of air quality, and public safety depends in part on better traffic control and regulation. The efficient consumption of resources, from energy to water, is essential for sustainable cities and communities. Addressing climate change, and being prepared for increasingly severe climate events, is a major technological challenge.

In preparing this report, the GSMA examined eight areas and more than 20 specific applications in which smart city technologies can make a material impact:

- **Environment:** Smart street lighting, air quality management, and waste management.
- **Transport:** Smart parking, traffic management, smart maintenance of transport infrastructure, and multimodal information
- **Safety:** Smart surveillance, smart prevention and identification, and disaster management
- **Utilities:** Smart water management and smart energy grid
- **Healthcare:** Dynamic patient routing, and epidemic detection and management
- **Communities:** Digital kiosks, public Wi-Fi, and digital/online citizen interaction
- **Tourism and entertainment:** Digital kiosks, crowd management, land location-based event marketing
- **Commerce:** Digital kiosks, personalised street advertising, and logistics

The potential in each area is enormous, and pilot projects have validated the impact of technology on wider city goals (such as connected CCTV monitoring, smart metering of water or electricity, and detection-based traffic management). But there are few, if any, examples of at-scale adoption or widespread impact (See Exhibit 2). One big challenge is complexity.

EXHIBIT 2

Source: BCG analysis

THERE IS AMPLE ROOM TO MOVE TOWARDS SMARTER SOLUTIONS

ILLUSTRATIVE EXAMPLES	- LEVELS OF COMPLEXITY (INCL. CONNECTIVITY REQUIREMENTS) AND BENEFITS +		
ENVIRONMENT	Connected bins notifying full for garbage truck routing optimization	Connected LED lights controlled dynamically in function of outdoor luminosity and amount of people	Underground waste vacuum system with automated sorting and recycling at the waste station
TRANSPORT	Detection-based traffic light priority order when no traffic (binary system)	Traffic light order based on number of cars awaiting, detected by cameras	Autonomous car sharing infrastructure with automated route optimization based on traffic and incidents
SAFETY	Connected CCTV monitoring the city	Predictive policing based on camera feeds and crowd analysis	Facial recognition of people from CCTV and automated tracking
UTILITIES	Smartmeter: consumption meter sends data to energy/water provider at regular intervals	Automated reporting to citizens about their energy usage and plan for optimizing energy use	Smart grid, enabling bi-directional energy flow with adaptive energy storage and power management
HEALTH	Clever repartition of patients in function of hospital capacity	Real time air quality measurement at granular local level	Body temperature and other health parameters monitored by on-street camera to detect epidemics
COMMUNITIES	"Fix-my-street"/3-1-1: non-emergency problems are risen from the citizen to the municipality	Digital kiosk widely installed throughout the city	e-participation of citizens into decision making of municipality
TOURISM & ENTERTAINMENT	Location-based event advertisement	Crowd management by localizing individuals to optimize crowd moves	Drone surveillance of large-scale events
COMMERCE	Smart lockers for last mile delivery	User-customized advertisement on street screens	Drone deliveries to decongest ground traffic
ACTUAL AVAILABILITY	WIDELY AVAILABLE	PILOTING PHASE	CUTTING EDGE

The Basics of Smart Cities Are Complex

In their simplest form, smart cities use information and communication technologies to collect and analyse data and to manage city infrastructure to achieve specific goals, such as maximising the efficiency of resource consumption or improving mobility. Ideally, smart city technologies focus on relevant use cases that have a material impact on sustainability, well-being and economic viability. Their impact, however, depends on cities' ability to enable wide-scale deployment of technologies and promote use cases across multiple applications. This requires fostering integration and cooperation among participants through data platforms and operational centers.

The macro case for smart cities is compelling, but the business case for individual participants can be more complicated. For a city of 1.5 million inhabitants, we estimate that the at-scale deployment of selected applications can unlock about €100 million of direct value annually and more than €250 million (and perhaps as much as €400 million) of indirect value (See Exhibit 3). But the analysis also reveals some of the reasons why smart city applications have yet to be scaled up.

EXHIBIT 3

Source: BCG analysis

AT SCALE DEPLOYMENT OF SELECTED APPLICATIONS CAN UNLOCK €100 MILLION OF DIRECT VALUE AND €250 MILLION OF INDIRECT VALUE

			Annual benefits, for a city similar in size to Barcelona (1.5m inhabitants)				
APPLICATION	**BASELINE**	**SMART CITY INNOVATION**	**DIRECT**			**INDIRECT**	
Potential Platform			Citizens	Industry	Municipality		
TRAFFIC MANAGEMENT	Timer-based traffic lights	Equipped with counting cameras; sequence adapted to traffic	€12-22M			€200-350M	20-35kT CO_2
SMART STREET LIGHTING	Timer-based LED lights	LED lights controlled with a multi-stage dimming scenario			€7.5M	17kT CO_2	
SMART PARKING	Parking meters with manual registration & surveying	Sensors detecting parked cars and system verifying if spot is payed	-€1M		€15-20M	€8M	1.5kT CO_2
SMART SURVEILLANCE	Dispersed street CCTV	Widespread, with image (activity and license plate) recognition; noise sensor to detect shots				-€55M	E.g., crime reduction through lower response time
DIGITAL KIOSK	No infrastructure	Interactive digital billboards displaying ads and providing services		€30M		Citizen engagement, connectivity, etc.	
SMART WATER MANAGEMENT	Analog water meters	Smart water meters frequently monitoring and sharing consumption	€16M	€6M	€1M	20Mn^3	
TOTAL			**€90–100M**			**€250–410M**	

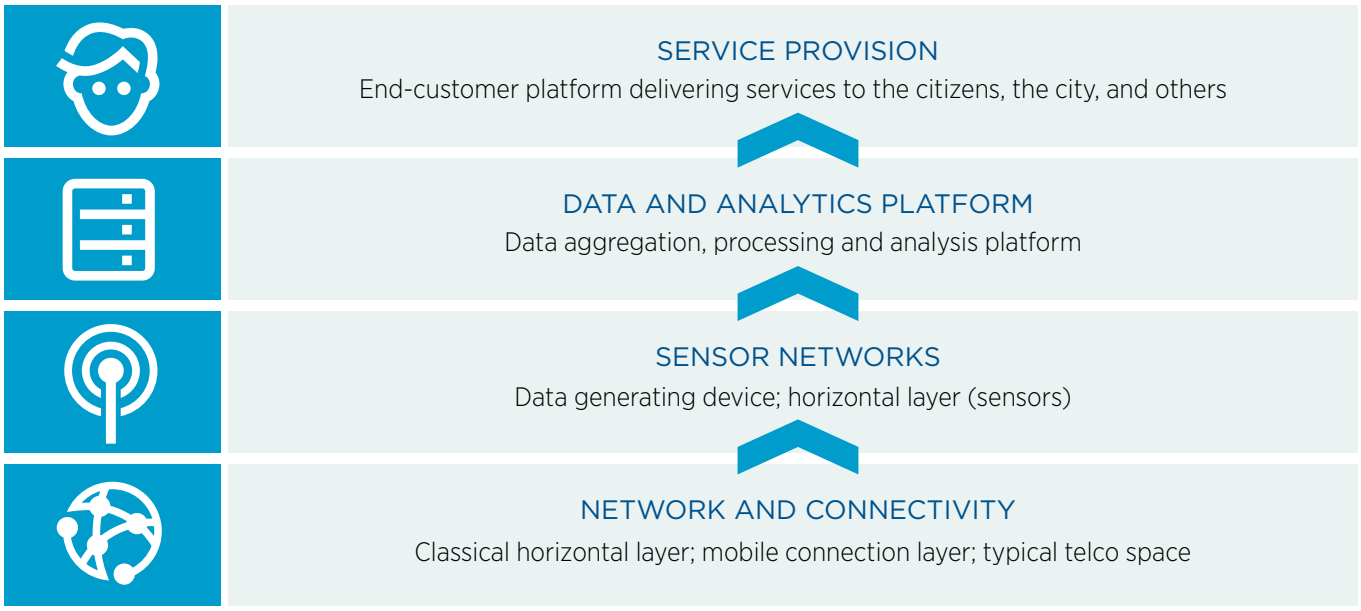
Several applications generate significant value for the community as a whole, but the value comes in the form of indirect and intangible social benefits. For example, more than 90% of smart traffic management benefits lie in the indirect value (such as time saved by motorists not idling in traffic). Direct value for both the municipality and private-sector players is typically limited and often does not justify the significant infrastructure investments they need to make. Consider smart surveillance systems, which require investment in widespread installation of connected cameras but do not create direct value in the form of a revenue stream to compensate for the cost.

To make matters worse, multiple public and private sector players interact at various levels of the smart city technological stack. (See Exhibit 4.) Municipalities set policies and targets and provide public funding and/or subsidies. Network operators and equipment companies build and maintain networks and provide connectivity. Tech companies provide the data and analytics platforms that handle data aggregation, processing and analysis. Hardware manufacturers make sensors and devices that generate the data that makes smart cities smart. Service providers deliver digital services to cities and their citizens. The ability to construct a value case that works for all players across this stack has been out of reach in many of the pilots to date.

EXHIBIT 4

Source: BCG analysis

THE LAYERS OF THE SMART CITY STACK



Some stand-alone applications can have viable business cases in particular locations with substantial needs (such as smart water management systems in wealthier, more well-developed cities). In other instances, "platform plays" ease the business case by spreading similar infrastructure costs across multiple applications. Smart traffic management and smart surveillance can both use the same camera installations, for example. (See the sidebar, Amsterdam's Vision for a SmartCity Platform Started from a Smart Lighting Platform.) In most instances, however, direct revenue potential is limited, especially for operators, whose participation is essential for network availability and connectivity. "A technology-first approach doesn't work well—the solutions need to be designed for the specific operational context and city ambitions; not just to demonstrate interesting technology," one industry executive said. Leveraging smart city deployments to reduce network investment costs—by trading the indirect benefits brought to society for reduced rental costs, for instance—can be more attractive for these companies.

Amsterdam's Vision for a Smart city Platform Started from a Smart Lighting Platform

The city of Amsterdam started with a simple application to turn municipal lighting on and off based on the amount of natural light available. It then added additional on-off settings that could be programmed remotely. More advanced sensors capture current weather conditions and surroundings and adjust lighting features, such as intensity and color, based on these factors.

More recently, the city has programed lights to attract people during events and integrated sensors to measure statistics about the crowd and video cameras for security and crowd analysis purposes. These devices have been connected to emergency services and police (although it should be noted that these features have triggered privacy concerns, which could impede further implementation). Today, lightposts feature integrated pubic Wi-Fi and communication devices, digital kiosk functionality via smartphone, and automatic push messages with advertisements that appear when pedestrians pass by.

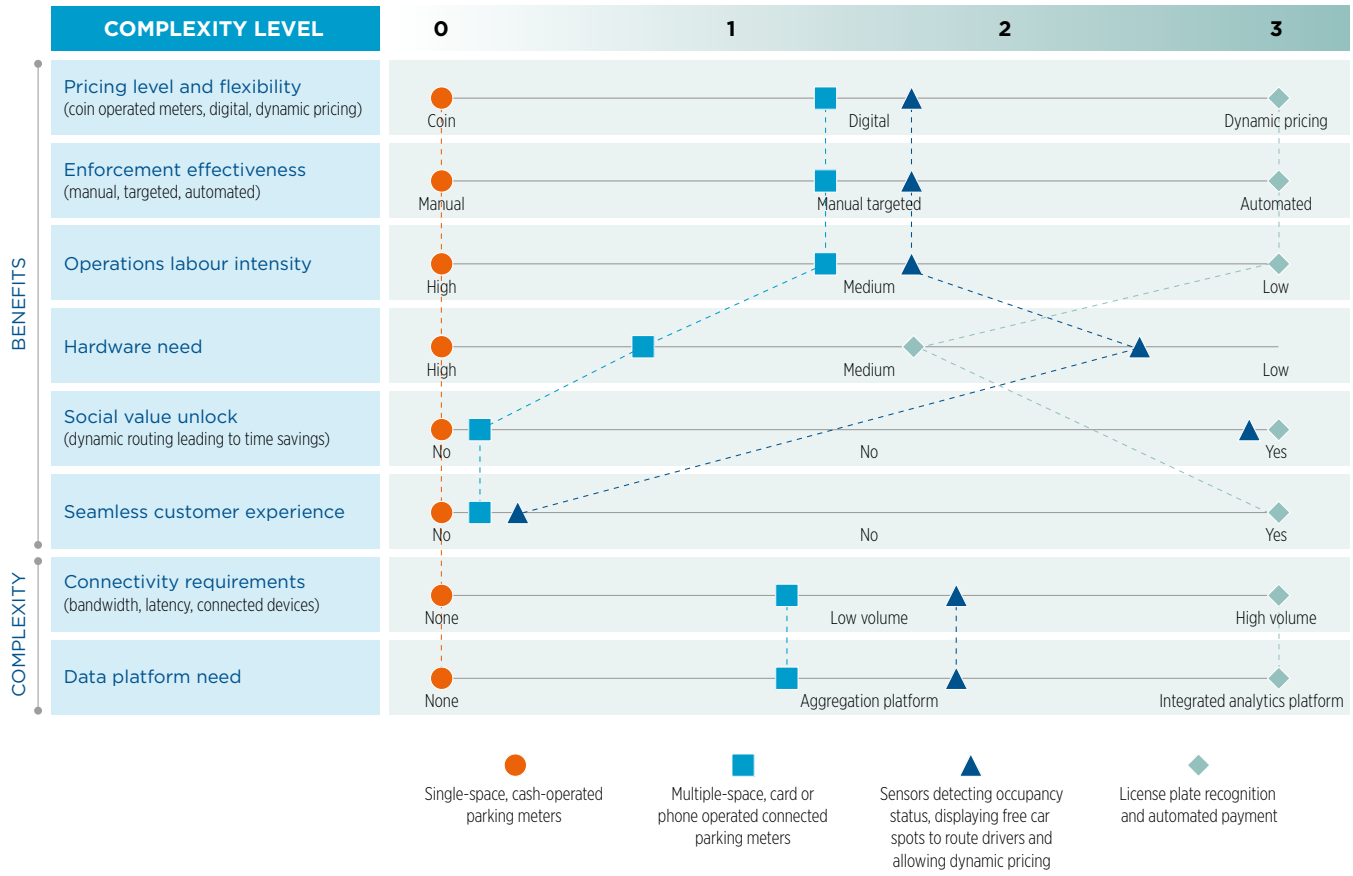
Moving to more complex solutions can unlock additional value but often at the cost of deploying additional connectivity and technology. Consider smart parking, which is only one application and far from the most significant, but it illustrates the challenges of scale and complexity in smart city solutions. (See Exhibit 5.) According to Intercomp S.p.A., which develops smart parking systems, when the city of Treviso, Italy, installed sensors to monitor the occupancy of parking spots, the city saw a revenue increase of 11%, in addition to the potential for significant operational savings in labor and other costs. But no city has yet used on-street cameras to identify license plates of parked cars and thereby to automate labor-intense parking enforcement, to maximize the monetization of parking spots, and to make finding available spaces quicker and easier for motorists.

Similarly, smart water meters monitor consumption, but it takes investment, probably by multiple players, in a more complicated combination of meters, a centralized data platform, and a dynamic pricing algorithm to reduce consumption when reserves are low. For traffic management, optimized route planning based on vehicle GPS data and incident information from city infrastructure is a much more complex and data-intensive undertaking than cameras and computers that dynamically adjust traffic lights based on the number of cars waiting to proceed in each direction.

EXHIBIT 5

Source: BCG analysis

MOVING TO MORE COMPLEX SOLUTIONS IN PARKING CAN UNLOCK ADDITIONAL VALUE BUT REQUIRES MORE CONNECTIVITY



This complexity is one big reason that many smart city efforts have focused on pilots rather than initiatives at scale. Research for this report found that funding is often provided for feasibility studies and pilots with single-project funding only rarely exceeding $10 million. (A smart city challenge in the US awarded $11 million to finalists for a single application at reasonable scale, but this is one of the few examples of larger funding for smart city solutions.[2])

City plans outlining multiyear ambitions focus largely on creating new pilots. Since most municipal governments are organised around different departments, each with its own specific responsibilities (buildings, water, police, fire), many efforts are siloed and do not come together in an integrated system. For example, it is quite common for emergency services such as fire departments to run their own digital systems which they are reluctant to give up in favour of a untested (from their point of view) cross-department integrated system. In addition, cities around the world often run similar pilots, but there is no mechanism for coordinating or transferring learnings among them. Common examples include the multitude of smart parking and smart lighting solutions currently being piloted.

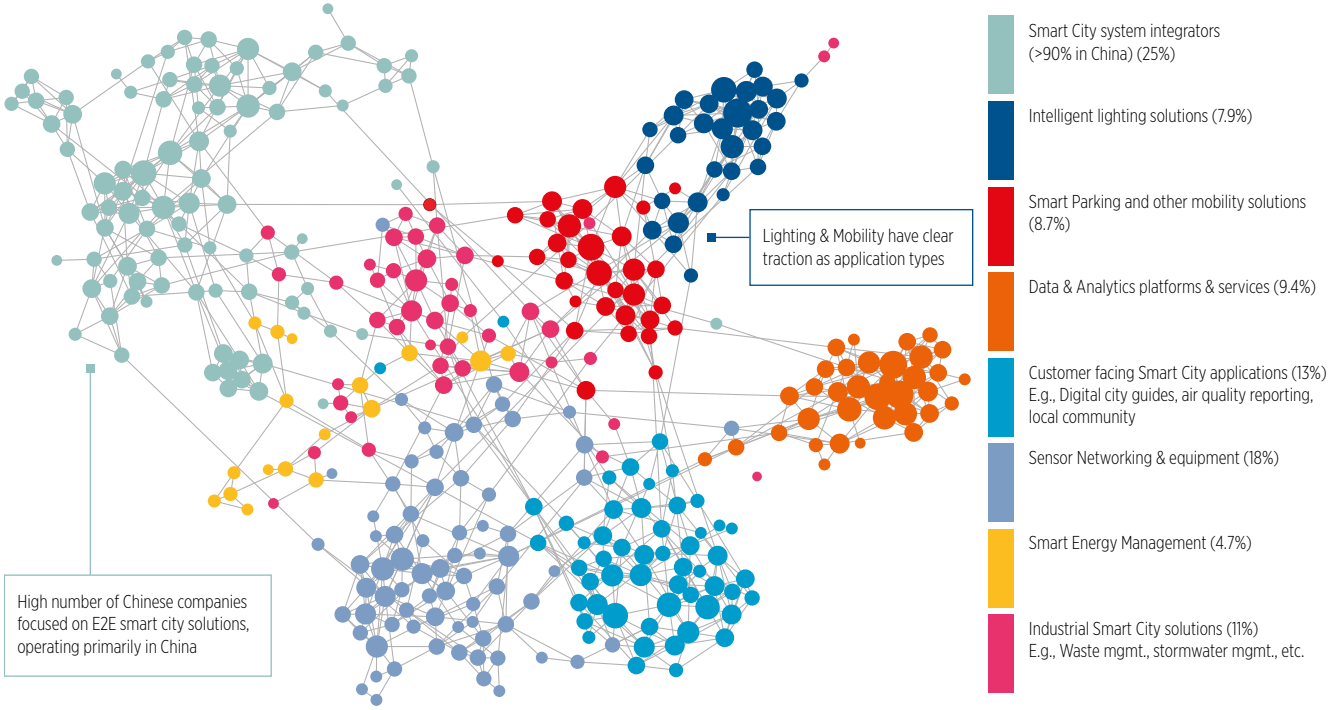
Thus far, the private sector has not had a strong business motivation to develop solutions at scale. BCG researched the areas of focus of some 380 companies involved in smart city projects. Only about a quarter concentrate on end-to-end solutions, and more than 90% of these are in China. The rest tend to concentrate on single areas of application, such as energy management (5%), parking and mobility (9%), data and analytics platforms (9%), or industrial smart city solutions (11%). (See Exhibit 6.) In addition, smart cities have yet to capture the concerted investment attention of major players. Of more than 1,900 investments made by nine leading tech and telecommunications companies since 2010, only 66—about 3.5%—involved smart cities[3].

2. https://www.transportation.gov/smartcity/what-comes-next
3. Quid, BCG Analysis

EXHIBIT 6

Source: Quid, BCG analysis

SMART CITY COMPANIES TYPICALLY FOCUS ON FEW SPECIFIC VERTICALS, OR HORIZONTAL LAYERS, IN THE STACK



Note: Company network with 381 companies. Colored by clusters. Sized by degree. Labeled by clusters.

Benefits for Industry

Network operators and technology providers have a stake in accelerated smart cities deployment. The potential for new connected devices promises additional connectivity and service revenues. We estimate that for each city of 1.5 million people, smart city applications can bring in up to €5 million of direct benefits to operators' core business (which represents about 20% of the estimated annualised capital and operating cost for 5G deployment in the same sized city). The benefits consist of €1 to €2 million of new connectivity revenue and €3 million from device sales and management. An additional €1 to €3 million can be realized through reduced infrastructure-rental and other access costs in places where such costs haven't yet been incorporated into a cost-based system to reduce overall infrastructure expense.

There is also the potential for additional benefits from an accelerated deployment processes. The combined impact is equivalent to a 2% to 3% increase in average revenue per user from mobile subscribers across the industry. In addition, smart cities open opportunities for new vertical use cases allowing operators to move up the stack and offer more high-value services. The timing also is propitious as smart cities support the case for 5G deployment—and vice versa.

There are good reasons for cities and industry to conquer the challenges of scale and complexity that have so far held smart cities back. Operators can play a key role. As one industry expert put it, "Operators can use their experience and long history in dealing with municipalities, unlike many of the technology players in this space." The next section examines the specific roadblocks cities and companies need to overcome.

Four Roadblocks to Progress

There are plenty of reasons for the small scale of smart city applications so far. One is that limited-scale projects involve fewer stakeholders, making it easier to move fast and avoid the need for interoperable systems, an increasing issue as more participants are involved. Investments are smaller and the business potential doesn't have to be fully clear at the start. Technology scalability is usually not a concern, and capacity requirements are limited. The data management parameters are manageable as the number of inputs is small and security and privacy implications are limited.

As smart city projects try to scale up, however, and move from pilots to larger and more complex deployments, they typically run into four major roadblocks. (See Exhibit 7.)

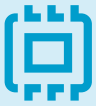
EXHIBIT 7

Source: BCG analysis

SMART CITY COMPANIES TYPICALLY FOCUS ON FEW SPECIFIC VERTICALS, OR HORIZONTAL LAYERS, IN THE STACK

ECOSYSTEM

A combined effort is required from an ecosystem of public and private stakeholders, which often have different agendas. Smart city solutions are often complex and require a consortium of public and private partners to come together and work out such critical issues as the business case, policy considerations, and technology hurdles. A disconnect between smart cities solutions and existing city problems, together with a lack of technology expertise in government offices, can result in misguided efforts that do not effectively address citizens' needs.



TECHNOLOGY

In some cases, technology cannot be deployed affordably at scale, the required infrastructure (in terms of latency and bandwidth) doesn't exist for some use cases, or the existing network infrastructure cannot support the number of devices required. Large-scale smart city applications are often limited by bandwidth and connectivity requirements. Specific advanced smart city solutions may require new technologies, such as edge computing, to be scaled up.

VALUE CASE

At scale, the investments are considerably larger, business cases are harder to demonstrate and intangible social or indirect benefits are not easily captured. A large number of initiatives do not proceed beyond the pilot phase because indirect benefits cannot be monetised and/or one of the private players cannot demonstrate a positive business case.

DATA MANAGEMENT

Complexity and risk increase as more data sources are connected. Privacy considerations and national and international regulations, along with the risk of negative press attention, can slow adoption.

By itself, each roadblock is a significant barrier, but the four also interconnect, slowing progress further. (See the sidebar, The Roadblocks to Smart Traffic Management.) Here is a more in-depth look at each one.

The Roadblocks to Smart Traffic Management

Smart traffic management systems seek to create safer, less congested traffic conditions with vehicle-to-vehicle and vehicle-to-infrastructure communication. Taking all the socio-economic benefits into consideration, including accident reduction, cuts in fuel consumption and emissions, and the less explicit costs of motorist delay, the pay-back on smart traffic solutions can be achieved within a couple of years. Rollout of these systems, however, has been limited to date, typically because more advanced applications and the scaling of solutions is limited by technological, political and funding roadblocks.

The most common smart traffic management applications include smart parking (identification and reservation of free parking spaces and digital payment), connected vehicles (systems that provide infotainment and software updates to cars via mobile transmission), vehicle-to-infrastructure communications (enabling vehicles to communicate with traffic infrastructure such as traffic lights or devices placed in the road) and, potentially, vehicle-to-vehicle communications (sharing information about surrounding traffic circumstances).

Success in each area has been limited. Smart parking has been applied in many cities either as a pilot or more broadly. But larger-scale smart parking solutions typically do not offer the advanced features, such as the ability to check for, or reserve, empty spots. In Amsterdam, for example, users can pay for a parking spot via apps such as parkmobile, and the city checks vehicles equipped with automatic license place recognition, but identification and reservation of parking spaces is not available. The popularity of connected vehicles is rising, but most manufacturers still only use this capability for infotainment systems. The city of Eindhoven in the Netherlands launched a small-scale pilot using vehicle-to-infrastructure communications, but broader rollout was deemed too costly with the current state of technology.

Smart traffic projects are typically managed by municipalities that do not have the required capacity and expertise to implement large scale, complex initiatives. Collateral considerations, such as job loss, undercut the enthusiasm of political leaders, and lengthy development and installation periods span multiple election cycles. As one industry expert said, “Investments are often linked to the political landscape; if a project does not deliver within the election timeline, it is less interesting for the municipality to invest in it.”

Security concerns with respect to technology abound, communication standards are often not interoperable, and more advanced data collection applications require 5G connectivity for bandwidth and latency reasons. Moreover, devices for advanced smart traffic management are often expensive and not yet ready for large-scale roll-out.

Public-Private Partnerships

Once they expand beyond the pilot phase, most smart city solutions, particularly more advanced solutions, require a consortium of public- and private-sector partners to work together. Participants typically include several municipal government offices, agencies, or departments; agencies of regional, state, or national governments; and companies operating at each level of smart city stack. Each participant has its own needs, interests, and priorities, and these often do not align with one another. Privacy and security issues and funding concerns can be roadblocks for government decision makers while business case and technology operability are frequent obstacles for private players.

In addition, competing private players' solutions leads to fragmentation of technology platforms and data aggregation standards. Complex systems require several stakeholders to incorporate smart city technology into their products and ensure the technology and data layers are compatible. Even when standardisation of technologies is achieved, the incorporation of new technology into each manufacturer's products can require a significant engineering effort on the part of the companies involved. For example, smart parking technology providers often have proprietary systems that do not communicate with each other, and this lack of interoperability has prevented many cities from being able to put in place a single smart parking network.

The lack of technology expertise within municipal governments makes it difficult for offices and agencies to effectively represent the city's interests, manage projects, or capture the benefit of smart solutions. The number of government layers of approval required for larger projects thwarts progress and frustrates private sector partners that are accustomed to moving at tech industry speeds. Elections pitting candidates and parties with differing priorities and points of view are a complicating factor and can cause bureaucracies to avoid taking on large-scale programmes that will be called to into question with every change in the political landscape.

Given their central coordinating role, a hands-off approach by government participants can result in lack of standardisation of technologies or limited representation of city inhabitants in program design. For example, the safety and disaster management systems built ahead of the 2014 World Cup and 2016 Olympic Games in Rio de Janeiro have limited ongoing benefit for much of the cityfull stop after city. Concentrated and focused on the wealthier section of the town, the smart camera system and many other initiatives were deployed for short term use, supplying little information for longer-term city planning.

The experience of one of the earliest cities to embrace smart city technology, Barcelona, illustrates the kind of issues that can arise across the ecosystem. While pilots can show initial success, scaling brings along a significant issue of interoperability of different systems and lack of common platforms. Barcelona set up 22 smart local programs, from smart lighting and energy to health and education. It has put a range of smart technologies in place, including a 500-kilometre network of optical fibre and sensors to monitor air quality, water management, smart parking and smart waste bins. Its solutions have helped reduce water used by city parks and improved ticketing, reliability and information in public transport systems. Smart street lights are used to attract people to events by turning them up rather than just saving money by turning lights off when there is no one in close proximity. The next step is to create an open-source sensor network, with common standards, connected to a computer platform managed by the city itself.

Still, there are multiple issues. City Hall has access to lots of data but insufficient technical capacity to use the data for decision making. Space-vacancy sensors in multistory car parks have been a big success, but poor interoperability of systems makes it impossible for drivers to effectively use the information when outside the car park, to reserve a parking spot in advance, for example. There are a lot of different silos in the stack, but no layer to help them interact. The city has now mounted a big effort to create a system to control and manage the data from the different silos.

Value Case

On the basis of financial value alone, the business case for smart city initiatives can be challenging, and many pilots, even when successful, are not scaled up for business case-related reasons. Quite often, the financial returns simply do not justify the investments. Operators, for example, are unlikely to make enough from additional Internet of Things (IoT) revenue streams alone to support building out the network infrastructure that are needed to support multiple IoT applications in the same area[4]. Cities face similar issues. Take smart street lights. Since the initial investment in new infrastructure and technology will only be recuperated over the long term, cities typically wait to install new technology until it is time to replace existing street light infrastructure, which can be decades away.

To be sure, there are big social and public benefits from smart cities, but this value is often not captured in investment models. Social benefits such as time saved or CO2 reduced, and intangible benefits such as health and safety improvements, are not monetized, and investors in the tech stack do not benefit, or benefit equally, from these outcomes. For example, as we saw in Exhibit 3, it is estimated that more than 90% of smart traffic management benefits lie in the indirect value generated by traffic data. A 10-minute reduction in travel time from a smart traffic light system has proven economic value, but this value does not accrue to the municipality, let alone to the companies making the investments.

Data ownership and access is another issue. Contracts often award ownership of the data generated by smart city sensors, monitors, and cameras to a small number of technology partners, limiting its value for other parties.

Some high value use cases require a substantial commitment of public funding (since they are not priorities for the private sector), which is difficult to secure. It is more likely committed to early-stage pilots than to scaling up programs or to more complex solutions. As one senior industry official said, "We are killing ourselves in the industry doing pilot after pilot. We need to start scaling programs." There are also multiple competing priorities. For example, smart traffic solutions can compete with public transport systems for funding.

Some cases can result in negative social or political impacts, such as loss of jobs, for individual departments, while growing employment at others. Smart traffic and parking systems require fewer traffic police and parking attendants. Smart waste management systems need fewer sanitation workers. Of course, these trade-offs are inherent to every technological innovation and will be offset in the long term by an increased need for new, digital, skills both in the municipalities and the industry, as the GSMA has laid out earlier[5]. While these impacts need to be managed, they should not impede the implementation of an attractive use case.

Sometimes, the intended value at a macro-level does not translate to the level of individual citizens and business. In 2002, the government of South Korea launched the new city of Songdo with an investment of $40 billion and the vision of creating a new way of modern living for more than 300,000 residents. The city aimed to be car-free, with 40% green space and bicycles as principal mode of transportation. Some 15 years later, it is less than half-built, and fewer than a quarter of its homes are occupied. Residents claim that the high cost of living is driving people back to Seoul, and they do not value the installed benefits as much as the planners expected. Companies say that the commute to Seoul is too long (more than one hour) for them to consider relocation.

4. See A Playbook for Accelerating 5G in Europe, BCG report, September 2018.
5. GSMA report: Delivering the Digital Transformation, 2017

Technology

While many smart city applications can be implemented using current networks and devices, technology remains a hurdle in widespread deployments or when applications require more connectivity or computational power than is currently built. For others, the main roadblock is the investment necessary to bring the technology to market at scale. The solutions are in sight, but a business case that attracts the requisite funding remains the critical missing link.

A big issue for data-intensive applications is limited deployment to date of high-bandwidth and connectivity infrastructure. The solution could lie in the transition to 5G networks, but the pace of 5G rollouts varies widely. To deploy the eight types of smart solutions researched, the mobile communications network in a city such as Barcelona would need capacity for an additional 800,000 devices, which translates roughly to 8,000 devices per square kilometre—or approximately four times the density supported by current 4G networks. Moreover, a number of applications have specific requirements with regard to bandwidth, latency, and maximum number of concurrent connections. While NB-IoT could solve many of these issues, the business case for the operators to wait and integrate these capabilities into 5G deployment is often better—especially as the 5G business will in part depend on such use cases.

In addition, the (edge) computing capacity necessary for real-time image recognition or running appropriate security algorithms that protect network communications from intrusion or tampering, is not commonly available for deployments at this scale. Similarly, technical specifications in terms of battery life and image resolution that are necessary for some smart city solutions have yet to be achieved.

Data Management

Data privacy and security issues can loom large in smart city applications. Regulations designed to protect user privacy can delay valuable, but privacy-sensitive, smart city applications whose effectiveness depends on the widespread collection of user data. For example, a smart water metering program in the UK ran into privacy concerns because there was no way for citizens to opt out (which would have compromised the usefulness of the system). In Brussels the installation of cameras on billboards to count passers-by caused public commotion and a request for a review by the national privacy commission. In Singapore, one of the most advanced smart cities, a government plan to install cameras linked to facial recognition software to "perform crowd analytics" and support anti-terror operations is raising privacy fears among security experts and rights groups.

Stringent data security regulations also can create uncertainty with respect to how to manage "unknown data." It's not always clear what data companies have access to—or that that separate data fields can be combined to create personal profiles—and therefore how the rules apply.

Security issues arise when critical systems become part of the smart city ecosystem. Critical or privacy-sensitive systems, such as those used for traffic management, require robust security to protect against malicious attacks, but this can delay development and implementation. As one city official said, "The tradeoff between cost and privacy control is a key challenge. It is too expensive to build our own data infrastructure and keep control of the data, so we need to rely on large tech companies and let them manage the data."

The risk-averse nature of companies and governments alike slows progress of smart city applications because of the potential for negative press attention. In China, the rollout of the Hangzhou "City Brain" project after a successful pilot has raised multiple security and privacy concerns. The system involves using data on road conditions and weather from hundreds of thousands of cameras to feed AI algorithms that help manage traffic and emergency response. It has shown success in reducing response times for ambulances, cutting travel times for motorists, reporting traffic accidents, and reducing crime. The project also has been cited for its dependence on centralised systems that can fail or be hacked, limited oversight and control, and privacy and data governance issues that need to be addressed.

Clearing the Way to Solutions

The need for smart cities is sufficiently great that solutions to the issues described in the previous section will ultimately be found, and the roadblocks will be swept away. The more practical questions are, how long will this take, what kinds of opportunities will be lost in the meantime, and how much value—social and financial—will be forgone? Municipal governments, private sector players, and operators can all take steps to accelerate progress.

The path to solutions starts with a city strategy to be executed by a combined public private ecosystem. City leaders need to align smart city initiatives with their principal city goals and take steps to ensure that socio-economic factors are included in the value case so that there are tangible means of demonstrating progress. Governments, with the help of other participants, must develop public-private value cases that help unlock required funding and show win-win scenarios for all stakeholders. All participants need to collaborate to create viable open ecosystems that allow innovations and technologies to spark, to facilitate monetisation and easy integration of new technologies for all stakeholders and to ensure that compatibility, privacy and security risks are mitigated.

It's a tall and complicated order, but Rome wasn't built in a day. Here's a roadmap for getting started.

Establish the Ambition and Strategy

Projects that support an overarching city strategy can help ensure that initiatives have long-term sustainability, they are designed for scale, and that social benefits are a part of the value case. Too often cities seem to focus on a particular technology or cost-reduction feature; they should start by defining solutions for the most-pressing problems they face. Technologies should have demonstrable socio-economic benefits for the city and residents, such as energy savings, effective water management, or traffic congestion reduction. The city of San Francisco, for example, has set up smart city projects for streamlining waste management, reducing traffic congestion and reducing energy—all supporting the main targets to achieve zero waste by 2020 and become carbon-free by 2030.

Cities can overcome the problem of expertise by building a dedicated smart city team with the responsibility to ensure that the ecosystem around smart city projects is successfully managed. Some cities appoint a CIO or smart city director to build the team and drive the strategy. A strong mandate can help such a team or leader prevent projects from falling victim to political election cycles and speed of approval by relevant city agencies. The CIO team also provides points of coordination with other cities for sharing success and best practices and avoiding duplication of effort. They can facilitate collaboration among different departments and agencies and provide a central point of contact for private-sector partners. Amsterdam has 40 people working on smart cities, of whom 15 are dedicated to the organisation supporting public-private partnerships and six devote their time to collaboration inside the municipality.

Industry can actively engage the municipality's smart city agenda instead of waiting for tenders or requests for proposals. Private-sector players can support the city's efforts at an early stage with knowledge and expertise that help shape the strategy and smart city ambition. They can share best practices and impact assessments from previous projects, which may facilitate politicians selling a project and securing the funding required. The smart parking solution in Amsterdam is working well and presents a business case for the municipality and the private players involved that could be replicated elsewhere. These companies can actively engage with other cities to expand rollout of their solution instead of waiting for the cities to consider a smart parking program on their own. A number of big companies—Cisco, IBM, and Accenture among them—actively pursue and shape smart city solutions with municipalities, often working in consortia with operators.

Create a Public-Private Value Case

In response to new types of needs, public and private sector participants are developing new models for funding and earning returns on smart city programs. New mechanisms such as social municipal bonds and development funds have the potential to monetise some of the social benefits for cities and therefore support the smart city value case. Some bond issues are linked to a city's realisation of the strategic ambitions and provide a return for achieving certain goals such as CO_2 reduction or congestion relief, essentially creating a pay-for-results funding mechanism. Funding for smart initiatives is available through regional funds set up for the purpose, such as the EU's Horizon 2020 Work Programme. The European Innovation Partnership on Smart Cities and Communities has significant amounts of investment funding available for smart city initiatives with potential for positive socio-economic impact.

Even if a smart city application does not offer a sufficient direct return on investment for all partners, private sector participants can often find ways to monetise the data platform and realise value from additional data-driven services, which also lowers the upfront investment for cities.

Even smaller towns or neighbourhoods within cities can come together to develop specific smart services. Some partnerships take the concept of shared funding to the individual citizen level. The transition to energy independence and a carbon neutral footprint for the village of Feldheim, Germany, began with the erection of four wind turbines on land owned by the local farming cooperative. Based on its early success, the program expanded to 47 turbines, with 99% of the electricity produced sold. But the local utility became a big roadblock when it refused to sell or lease its electrical grid to the village. Most communities might have pulled the proverbial plug, but Feldheim banded together to build its own parallel smart electrical grid and heating network, funded by a combination of renewable energy company Energiequelle, EU subsidies, capital loans, and personal contributions of €3,000 from each villager. The new grid was switched on in late 2010. From that date Feldheim has been fully carbon-neutral, and it opened Europe's largest battery energy storage facility in 2015.

Mobilising the community behind a common goal can result in a strong mandate and value case where everybody benefits. While the scale of Feldheim is small, the roadblocks it overcame by creating an aligned community can also apply to large city neighbourhoods.

By engaging with cities, operators can potentially find innovative solutions for closing the gap in their 5G business cases, which both addresses a broader public-private need and provides necessary connectivity for advanced smart city applications (especially those with high IoT capacity requirements). One high-potential route is through pursuing synergies in the deployment of communications networks and other smart city infrastructure, such as smart street furniture that can also host cellular equipment. Such synergies also offer the opportunity for accelerated rollouts.

Of course this also a double-edged sword. Many argue that such local and municipal fees for access to infrastructure, rights of way and even applications for deployment are often excessive and constitute a hidden tax, particularly when not tied to actual costs. In general, lowering fees drives more investment. Some national regulators have recently taken active steps toward ensuring fees are reasonable and cost-based.[6] Operators and governments need to consider the best way to improve the telco business case across all use cases – smart city and others – to drive innovation and growth.

Private players that can present a proven integrated solution (perhaps sourced from its experience elsewhere) can help reduce the ecosystem complexity for municipalities, accelerate decision making among other stakeholders, and ensures openness by design. Consortiums around particular solutions can be built from successful pilots or projects copied from other cities. For example, a consortium led by Dutch telecom provider KPN that includes Cisco, Philips, and Alliander has combined the companies' collective expertise to pilot advanced smart lights in Amsterdam.

Amsterdam has also started AmSMARTerdam, a city community accelerator for public private partnerships. The aim is to accelerate innovative solutions for metropolitan issues of a social, economic, and ecological nature by sharing knowledge and collaborating. It also helps the city gets solutions by organising events involving entrepreneurs and municipal decision makers around key city problems or strategic topics. The platform is open for any start-up, project, or company to join (there are several hundred projects at the moment). The platform is managed by a team of more than 40 people, with 15 dedicated community builders and project managers and supported by IT specialists and senior city advisors.

6. In September 2018, the United States Federal Communications Commission issued new rules that, in part, place limits on the fees that can be charged by municipalities for access to infrastructure for small cell equipment. Similarly, the Romanian regulator ANCOM issued draft rules in 2018 for maximum tariffs that may be charged by municipalities for rights of access to public properties for the deployment of telecom equipment.

Build an Open Ecosystem

Even though closed data platforms often can be better commercialised by investing parties, open ecosystems will generate maximum value for cities and private players and help foster innovation. Promoting technology investment in open, scalable systems allows established companies, start-ups and citizens to innovate. Multiple models are possible, including fully open platforms, pay-gates for access, and free or preferential access for academic or start-up users. The city of Chicago has started the Array of Things project, which makes data publicly available with the aim of inspiring residents to create "all sorts of applications taking advantage of the data." Similar initiatives are in place in San Francisco, Amsterdam, New York, among other cities.

Making the general public part of the ecosystem also has the benefits of providing transparency about how data is managed and ensuring that privacy concerns are raised at an early stage, before large investments are made. (See the sidebar, Tackling City Issues with Open Platforms in San Francisco.) It serves as a natural filter for eliminating low-value use-cases that do not achieve sufficient public buy-in. Citizens can share their own data, engage with the ecosystem, and potentially work with the data themselves. They have the opportunity to assess use-cases and make trade-offs on whether personal data can be used for these cases or not.

Clear privacy and security guidelines make it simpler for all stakeholders to understand the ecosystem, comply with its requirements, and manage compliancy with local, national and international privacy regulations. Ensuring clarity on accountabilities among partners in the ecosystem can help drive compliance. Anonymised and aggregated data still offers great value for most smart city applications as a wide range of applications requires no personal information. Data can be anonymised at the source before entering the data platform. For example, the Array of Things project in Chicago established its own privacy policy for their data platform with respect to personalised data. The platform limits access to any data that is personally identifiable. Image data is converted into numerical form and encrypted at the point of access before being sent to the server. Most data is made publicly available only in aggregate (non-individual) form.

Tackling City Issues with Open Platforms in San Francisco

The city of San Francisco, together with the Municipal Transportation Agency (SFMTA), has set the ambition to decrease traffic fatalities, reduce single occupant trips, and cut transportation-related emissions, all by 10%, before 2020. The city also aims to achieve zero waste (nothing goes to a landfill) by 2020, and become carbon-free by 2030.

Several large-scale projects are underway supporting these ambitions. For example, the Muni Forward project integrates several smart traffic management solutions: traffic signals hold green lights for oncoming muni trains, an open data platform, DataSF, has been set up, and legislation has been implemented to support the goal of zero waste. San Francisco OpenData is the city's open data portal and a product of the official open data program launched in 2009. More than 800 datasets have been published from more than 30 departments. More than 60 applications have been developed on the platform. Opening smart city data allows innovation to spark and citizens to become more engaged in their community.

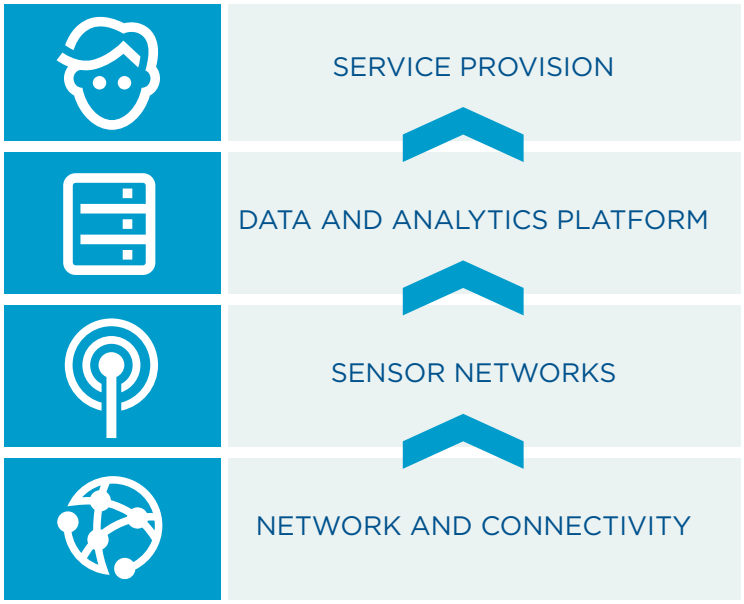
Roles for All Players

Government, private players, and operators all have a role to play in accelerating smart city initiatives. (See Exhibit 8.)

EXHIBIT 8

Source: BCG analysis

TELCOS, PRIVATE COMPANIES, AND MUNICIPALITIES HAVE TO JOINTLY BUILD OPEN ECOSYSTEMS



Municipalities need to ensure the data platform is open, secure and respects all privacy regulations to make it possible for citizens and innovators to work with the data and deliver additional value to the city

Private smart city companies have a role to play to make sure their product can be integrated into a unified data layer. Use of open standards and creation of suitable APIs are ways to ensure interoperability

Operators can make it possible to accelerate the creation of an open ecosystem by installing a standardized and easy to integrate 5G communications layer making it possible for a wide variety of smart city devices to communicate

The design of open eco-system is trade-off between private and public value as for private players it is often more interesting to create a closed off system to prevent competition from entering the market and to create data monetization opportunities. This limits socio-economic value for the city. However hybrid options exist, e.g., make it open for public institutions and small startups only, introduce pay gates for private players so that data management is monetized

National governments can set goals for the outcomes smart cities can achieve, such as reduced carbon emissions, improved air quality, and safer streets. These can be linked to the United Nations SDGs. Municipalities need to ensure the data platform is open, secure, and respects all privacy regulations. They can weave smart city initiatives into existing strategy to solve actual problems and create socio-economic value. A dedicated team with an appointed leader may be necessary to manage smart city projects, facilitate collaboration, and gain access to data across departments.

Private companies should make sure their products can be integrated into a unified data layer. Use of open standards and creation of suitable application programme interfaces are prerequisites to interoperability. Companies should look to actively engage with municipalities' smart city agendas instead of waiting for tenders or requests for proposals. They can help accelerate adoption by submitting proposals as integrated consortiums and developing solutions that have potential to scale across cities but maintain flexible to local problems.

Assuming a regulatory environment conducive to network deployment, operators can accelerate the creation of open ecosystems by installing a standardized and easy to integrate 5G communications layer that provides a longer-term roadmap towards 5G. They can start with current technologies from the 5G family, such as narrow band IoT, making it possible for a wide variety of smart city devices to communicate. They can work with public stakeholders to identify win-win scenarios in network deployment and to create public private value cases in which all participants realise adequate returns.

Cities are not born smart. Nor do they necessarily mature into thoughtful organisms. Yet managing their growth in intelligent ways is essential to our future, which can also be socially beneficial and financially profitable for urban stakeholders. The track record to date points to what is possible if ecosystems of public and private sector participants can come together to surmount the dual roadblocks of scale and complexity. Building smart cities is one of the defining challenges of our time.


gsma.com/publicpolicy

GSMA HEAD OFFICE
Floor 2
The Walbrook Building
25 Walbrook
London EC4N 8AF
United Kingdom
Tel: +44 (0)20 7356 0600
Fax: +44 (0)20 7356 0601