
# Smart Parking

## A Guide to Ensuring a Successful Mobile IoT Deployment


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The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with more than 300 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces industry-leading events such as Mobile World Congress, Mobile World Congress Shanghai, Mobile World Congress Americas and the Mobile 360 Series of conferences.

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**About Smart Parking**

Smart parking using Mobile IoT is one of the best tools a city has to solve parking and congestion issues. This guide explains how a city or parking operator can best approach a smart parking project and what steps they need to take to ensure success.

To find out more visit: **www.gsma.com/smartcities**

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# Introduction

Parking is going through a disruptive shift as technology enables new ways of maximising utilisation of parking spaces, and drivers become more demanding of using apps and other services to find available spaces.


Parking is a generator of revenue for the city, facilitates economic growth and is a factor in improving quality of life in many cities. Giving drivers access to parking spots in locations near to where they live, work and undertake leisure activities is crucial to ensuring that a cities' economic prosperity thrives. Many of the issues cities experience with pollution and traffic can be traced directly back to poor management of parking utilisation:

- **Vehicles circle city streets looking for parking**
- **New vehicles enter cities even when parking facilities are full**
- **Vehicles queue waiting to enter and leave car parks**

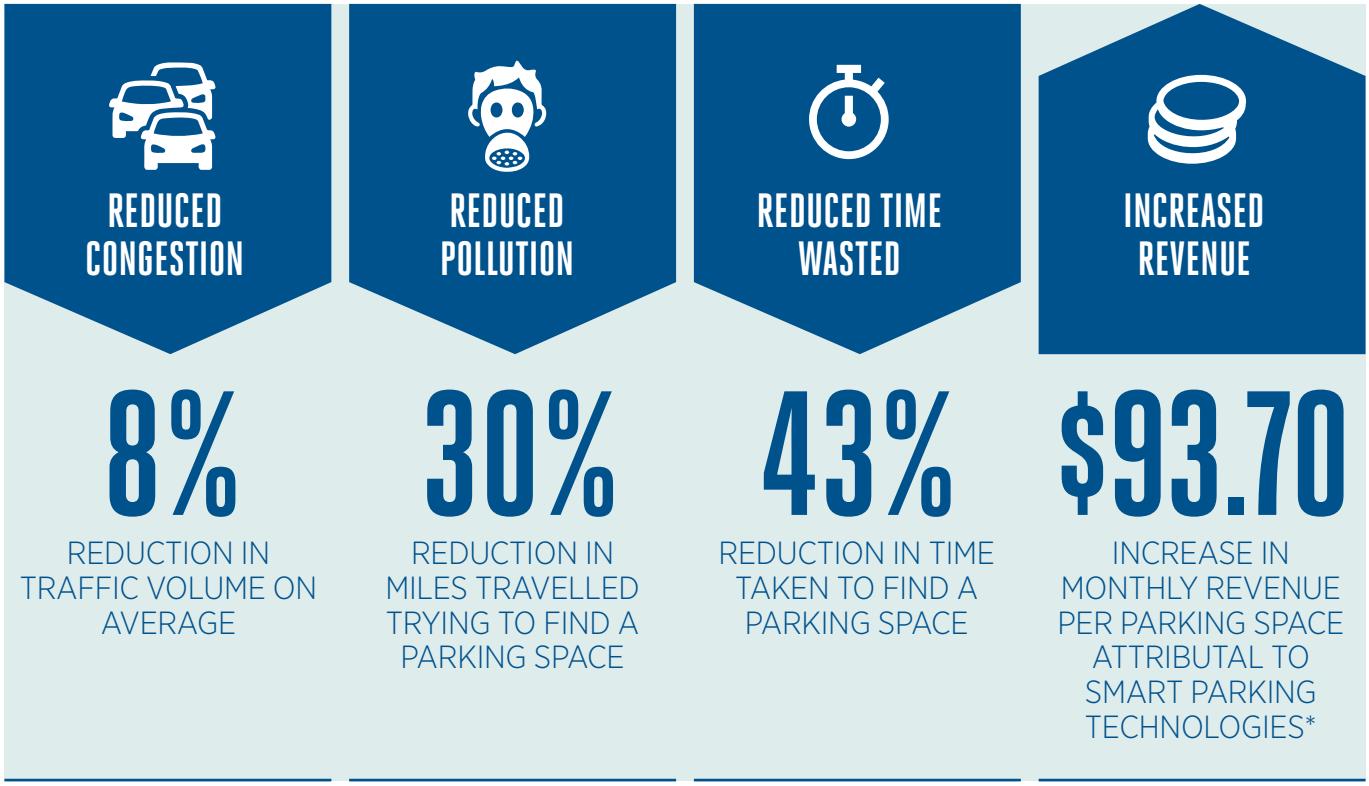
This additional movement creates traffic and increases vehicle miles travelled – which means more pollutants are generated. The indirect effect of this is wasted time and money. Businesses suffer as people cannot reach them, and productivity is affected by people being late for work, school and other appointments. By managing parking demand and supply in a more effective manner, these issues can be reduced or removed entirely.

The GSMA has carried out studies with Machina Research focused on San Francisco's SF Park smart parking deployment covering 19,250 spaces. The research shows that where smart parking systems have been installed, the time taken find a parking space can be reduced by up to 43%, vehicle miles travelled can be reduced by 30% and traffic volume decreased by 8%. The monetary benefit of the increased revenue attributable to the use of smart parking technologies was $98.70 per parking space.

The increasing emergence of electric vehicles also means that parking increasingly needs to be segmented by vehicle type, and smart parking allows for different segments to be handled in different ways. Disabled drivers, delivery drivers, families and vehicle types can be managed in an inclusive way, with priorities given where appropriate. In the not too distant future, smart parking will become an essential tool for autonomous vehicles in both navigating around a city and parking themselves in appropriate locations.

Mobile operators are at the heart of this change, providing advanced solutions to cater for the needs of Smart Parking. Newly developed Low Power Wide Area (LPWA) networks, also known as Mobile IoT networks are designed specifically to support the IoT sensors and data that enables smart parking. These networks are designed to be secure, scalable, future-proofed and operate cost-effectively.

## BENEFITS OF SMART PARKING




* Machina Research – San Francisco's SF Park smart parking deployment

# The parking value chain

Before investigating and procuring a smart parking service, it helps to understand the parking value chain, the stakeholders within it and their desired needs from any new technology driven solution.

## SMART PARKING VALUE CHAIN

| Parking Management | Parking Revenue | Parking Optimisation | Parking Integration |
|---|---|---|---|
| On Street / Off Street | Ticketing / Permits | Display Signage | Adaptive Demand link to city services |
| Land owner | Billing | Apps | Navigation |
| Installation | Enforcement | Multiple site overview | Autonomous Vehicles / EV |
| Parking Operator | | | |
| Communications | | | |

## PARKING MANAGEMENT

There are a number of stakeholders whose views need to be taken into account when building a set of requirements for a future smart parking service.

One of the key considerations is if the parking to be provided is on-street, off-street or a combination of both. On-street parking will have more complex needs, for identifying available spaces and ensuring revenue collection from parked cars, than off-street parking where vehicles typically have to pass through entry and exit points which can be controlled. Also short term parking spaces may have different needs than long term with short term often being in higher demand, resulting in a more defined need for tighter parking controls to ensure that vehicles do not overstay and short term parking is paid for in full. Smart parking enables new billing models for this type of parking – mobile payments combined with space utilisation data can mean per minute parking charges rather than flat rate in some locations.

Who installs parking sensors and controls also needs to be considered. In a new build car park this may well be the construction or fit-out company, but in existing car parks and locations, retro-fitting of intelligent barriers, cameras and in-pavement sensors could come from a number of stakeholders including building managers, parking operators and cities themselves. Additional equipment installed to manage parking space utilisation and ticketing obviously means additional costs and complexity.

Network coverage is crucial for both on-street and off-street parking locations. Mobile IoT offers wide area coverage as it is based on existing mobile networks. It is designed to penetrate deeper indoors and underground than existing networks so it can be used in a wide variety of car parks.

Maintenance of parking sensors can be expensive, so Mobile IoT sensors offer a very long battery life so that once installed, sensors do not need to be re-visited.

## PARKING REVENUE

For cities, car park operators and landowners, billing for parking is either a crucial source of income, or a valuable control mechanism for driver behaviour. Thus, ticketing for parking and enforcement of payment is a core part of the parking value chain.

Smart parking can help with both of these attributes - income and behaviour - by applying different rules in common ways. By ensuring that there is information available on parking utilisation, the city can ensure that parking tariffs are designed in such a way as to either encourage or deter people from parking in certain locations. At peak times, prices could be high to maximise revenue, whereas off-peak tariffs can be lowered to encourage people into city centres for leisure activities. Accurate billing can be based on how long a vehicle is parked for, and IoT sensors allow cities to measure this precisely, meaning that per minute billing could be used in some scenarios. This is particularly valuable for on-street parking, which does not have the entry and exit points of off-street parking, and so time parked is harder to measure and enforce.

To enable accurate billing, parking sensors need to know exactly when a car arrives and departs from a parking spot. Mobile IoT networks offer real-time messaging so as soon as a space is vacant, a message can be sent to the billing system to charge the driver.

### Identity

Billing and subsequent enforcement of non-payment relies on being able to identify the vehicle that was parked. There are a number of ways of doing this.

- **RFID tags.** These can be read by appropriately positioning readers on entry, exit and pinch points.
- **Licence plate readers.** These can record every vehicle passing entry and exit points and accurately record the licence plate of the vehicle.
- **Permits.** Can be used to store the details of vehicles who have pre-paid to park in certain locations such as residents parking zones.
- **Manual identification.** The use of parking officers and paper tickets can be used to identify vehicles and payments.

IoT can support all of the above methods, whether it be real time transmission of camera images for vehicle identification, or connecting handheld units to check vehicle identity and payment, there are a range of options available to cities and parking operators to support identity of vehicles, and any special circumstances that may need to be applied.

Security is crucial when identifying cars and recording payments. A breach of privacy can destroy faith in any parking service. Mobile IoT is designed to be secure, and all data gathered and transmitted is secured end-to-end meaning that it cannot be accessed by those without authority.

### Payments

Hand in hand with vehicle identification is payment for parking, which can be in advance or in arrears, depending on the mechanism chosen by the operator. Mobile payments are a helpful new tool in ensuring that paying for parking is secure and simple. Mobile payments can be made by a number of means, including through apps, mobile banking or contactless payments. With the introduction of smart parking, mobile payments can move to the next phase. Smart Parking allows for drivers to book and pay for a space in advance of arriving, pay in arrears by the minute and enables the city to use dynamic tariffs which change through the day to maximise parking utilisation and revenues. Payment for all of these services can be fully automated and secured, meaning that collection and enforcement costs can be reduced and driver satisfaction improved.

## PARKING OPTIMISATION

The information available to drivers, cities and parking operators increases hugely when intelligence is applied to parking services. Cities and operators looking to deploy smart parking should ensure that the data which will be generated by smart parking services is not held in silos, but is accessible by relevant stakeholders to ensure that a suitable approach to parking can be taken.

Smart Parking will change the way that parking is used. Display signage and apps that are used today can be made much more dynamic and let drivers know not just if a space is available, but where those spaces are, how much they cost and how long a vehicle can park there for.

The IoT allows cities, parking operators, app providers and even private residents with garages to dynamically offer parking throughout the day. The data can be extended to provide enforcement teams with details of parking availability and let them answer queries on the spot, and allow comparison with any contentious matter that the driver may report. It can also allow integrated management of other city infrastructure such as public transport and air quality sensors to ensure that parking, traffic and travel are seen as an integrated whole across the city, with all stakeholders involved. For example, parking charges can be based on vehicle emissions, so heavy polluters pay more than cleaner vehicles. This can be tied back to air quality date to show improvements in the environment.

The success of integrating data from disparate sources together relies on the continued security and thus privacy of that data, and not all parties will be willing to share if an effective security methodology is not in place. Parking operators and cities must ensure that all their service providers and technology partners are able to offer secure communications and handling of data.

IoT big data allows for the sharing of IoT and context data so solutions utilising data from multiple sources can be developed. For parking, IoT parking sensor data could be combined with weather, air quality, traffic and other transport data to provide an analysis of traffic and parking trends and enable dynamic transport and parking regimes.

## PARKING INTEGRATION

The city, and the people and vehicles that use it are being transformed rapidly by the use of mobile technology. Already IoT sensors, mobile apps, mobile payments and smart parking are revolutionising the ways that city approach their parking provision. At the same time, cars are beginning to become connected to all manner of services, meaning that soon parking availability will be able to be transmitted direct to the driver's dashboard. And in the not too distant future, autonomous vehicles have the potential to completely change our cities environment and parking provision will have to adapt to the new demands that this change brings.

Once data on parking availability is generated, it can be linked directly into a navigation system and direct the driver to the precise parking spot. Combined with mobile payments, this means that parking spaces can be reserved in advance before a driver even enters the city, cutting down on congestion and pollution.

Integration with wider transport networks is also an important consideration with many integrated services including out of city parking at transitional transport hubs as part of their offering. Parking usage can be used to understand potential public transport demand, and where parking spaces are actively removed to encourage alternative modes of travel, intelligent decisions are able to be taken about how best to balance different needs across the city.

Drivers of electric vehicles, and in the future, autonomous vehicles have specific requirements for parking. Obviously electric vehicles need to have at least overnight parking next to a charging point, which can be managed with today's smart parking services through vehicle classification and prioritisation. Underpinning all of these stakeholders are the communications service providers who are able to link the different components together and the parking operators themselves who are able to join together the elements into a packaged, managed service which the city can use to their advantage.

Mobile networks are future-proofing themselves with the introduction of Mobile IoT leading to the support of massive numbers of IoT connections. These networks are standardised, upgradable, and offered in licensed spectrum ensuring future service support.

# Communications Technology Procurement

Communications and big data technology drives the success of smart parking and is important to make the right choice. Cities or parking operators need to be sure that their technology selections are fit for purpose and will provide a base for building new services into the future.

Choices today will need to be used throughout a critical period of smart cities growth, and will need to adapt to many technological and behavioural changes on the horizon from the increase of data and decision making available to drivers to the shift towards autonomous vehicles. Selecting a solution which will not adapt to future needs could be a costly mistake.

Cities and parking operators need to take a holistic approach to their choice of communications and platform provider and should be thinking of several questions to ask, such as:

| Interest | Question | Answer is relevant when |
|---|---|---|
| Performance | Is the system able to scale to meet your demands? | You intend to connect more than one location; you intend to have real-time updates. |
| | What are the message delivery times? | You want to use the system to provide ticketing information; there is a high turnover of spaces. |
| | What is the network coverage? | You intend to offer a service across a city; you intend to connect spaces in buildings. |
| Data | Does the service support open data formats? | You intend to use other systems to manage or bill for parking services. |
| | Does the platform support Big Data? | You intend to analyse data for trends or have an overall view of city transport demand and supply by combining with other data feeds. |
| Security | Does the network support end-to-end encryption and authentication? | You need to meet a required security or privacy standard. |
| Communications Infrastructure | Does the network operate in licensed spectrum? | You value high quality of service and low risk of interference. |
| | What additional infrastructure is needed to support the service? | You want to keep your capex costs low; You don't want a complex implementation. |
| | Can the service provider be changed? | You want to avoid vendor lock-in and re-negotiate contracts periodically. |
| | Does the service have a roadmap to new service features? | You want to take advantage of new service features as they are introduced. |

Mobile IoT is a crucial enabler for smart parking services. It offers a standardised approach to multiple smart cities services. It is designed to offer improved coverage, long battery life and lower overall cost, along with a low risk approach to implementation. Mobile IoT is already being deployed for smart parking in many cities in Europe, America and Asia, proving itself a capable way to improve services and access open data.

# Partnerships

Cities, parking operators and car park owners should be looking to achieve long term, flexible partnerships with their suppliers. All stakeholders in the value chain should be seeking a mutual relationship with each other that allows for flexibility in parking provision and use of technology to create efficiencies, build better services and maintain customer satisfaction.

When looking to establish partnerships with mobile operators and other suppliers, cities and parking operators should ask themselves how they can maintain openness and gain the best cost to operate a smart parking service. This may mean strategies such as outsourcing parking operations or entering into procurement partnerships with other cities should be considered. A smart cities vision is also key to ensuring that the partnerships for smart parking are a success. Procuring a service in an environment which is defined by a strategic approach across all city departments means that projects and procurements can be executed in confidence. Collaboration across different departments ensures that partners are suitable for a range of projects, data gathered can be applied into other systems, experience can be shared and errors are less likely to occur.

## BUSINESS MODELS

The deployment of a smart parking service offers cities and parking operators the opportunity to review their business model and potentially take steps to approach parking and the data it generates in different ways. Smart Parking enables the city, value chain partners, citizens and other stakeholders to approach parking in a different way, and this could be reflected in the services financial model and thus requirements. Partners such as app providers and vehicle manufacturers offer new ways to monetise parking provision, and allow the cost burden to be spread in more ways than today. The data available from a smart parking service opens up new charging models and value added services, many of which could be made accessible through integration into various subscription and access models. Innovation is driving change in smart cities and smart parking is no exception. The technology will drive new premium parking, vehicle integration and parking-as-a-service models. Disrupting the current market model should be a consideration of the city of the future, and the city and parking operators must be able to take advantage when the opportunity arises.

The financial model for smart parking solutions can be innovative in its approach for the reasons outlined above. Budget constraints can be addressed through alternative funding models, with grants, asset leasing and smart investment models all being used to alleviate traditional funding constraints.

As the service grows it is important to use the data generated to create new insights that can provide financial and service remodelling opportunities. For example, data sharing with other departments can mean that congestion charging could be linked to parking availability, meaning new revenue potential and cross-departmental budget allocations can be altered in favour of one or the other.

Smart parking offers new ways to monetise data generated from drivers and spaces. Mobile operators can discover more meaningful intelligence about a cities' parking usage enabling a greater range of value added services. This includes anonymised data about where people begin their journeys, not just where they end them, how many people travel together and where people visit after they have parked in certain locations.

# KPIs

## Cities and parking operators must define desired outcomes before embarking on a smart parking deployment, use these outcomes to define KPIs in the service scope and ensure that potential partners are aware of what is needed to be delivered by the live service.

For each outcome, separate KPIs should be defined. To go further, KPIs can be used to develop a programme framework which can demonstrate the relationship between parking behaviours and wider impacts on the city. So if one of the cities strategic objectives is to reduce traffic, parking services can show that a decreased time to park results in less miles travelled, meaning less traffic on the roads. This in turn means that the business case for parking can become more dynamic with benefits shown across the city.

Typical KPIs that the city or parking operators may want to investigate include:

| Parking Usage | Parking Management |
|---|---|
| ■ How many hours per day is the space occupied<br>■ How many vehicles occupy a space per day<br>■ The reduction in the time it takes drivers to find an available space<br>■ Reduction in vehicle miles travelled to find an available space<br>■ User satisfaction with the parking service | ■ Parking revenue<br>■ Cost to manage per space or per location<br>■ Parking profit margin<br>■ Sensor installation times<br>■ Smart parking maintenance costs |
| **Smart parking services** | **Technology Characteristics** |
| ■ Data availability and access rates<br>■ % revenue collected<br>■ Payment success rates<br>■ Enforcement actions needed<br>■ Security of parking location | ■ Number of messages sent/received<br>■ Message delivery success rate<br>■ Message latency<br>■ Battery life of sensors<br>■ Open data access<br>■ Network coverage |

Tracking of performance and benefits will be key to ensuring that the smart parking service is a success. Monitoring these KPIs against pre-set objectives will allow the city to dynamically change their parking offer to drivers to ensure that performance targets are met. For example, tariff changes can alter driver behaviour quite significantly. Any problems that are identified will need to have ownership and mitigation plans to prevent loss of citizen and city engagement.

# Route Maps

## Implementing a smart parking solution requires an approach that is flexible and able to engage relevant stakeholders in changes needed to make maximum advantage of any investment.

"Starting small" is a good way to get up to speed with new methodologies whilst reducing the risk of mistakes which are difficult to reverse. Building upon this initial step with a series of iterative changes as the project grows will ensure that the full commercial service is more likely to be sustainable and deliver citizen engagement. The core stages of growth for a smart parking service are outlined below.

| STRATEGY & SCOPE | PILOT | ESTABLISH | SCALE | EVOLVE |
|---|---|---|---|---|
| Identify issue to be resolved | Refine processes | Incremental Go-live | Scale to multiple sites | Monitor performance |
| Define required outcomes | Test network performance | Live Data integration | Introduce new public services | Adjust service parameter if needed |
| Secure budget commitments | Understand installation needs | Apply lessons learnt and changes | Publish open data APIs | Undertake maintenance |
| Secure stakeholder commitments | Generate test data | Establish trusted foundation system | Integration with city dashboard | Sharing learnings wit other cities |

| SMART PARKING | | | | |
|---|---|---|---|---|
| Identify role of landowners and parking operators | Ensure parking cameras, sensors and payments are interoperable | Understand system constraints for future modelling | Integrate parking with other city data | Establish baseline parking parameters |
| Research what triggers are needed to change driver behaviour | Test sensor performance and durability | Undertake data integration with billing system | Educate public in new parking service | Put in place clear accountability and governance structures |
| Compile data on current parking usage | Sanity check to ensure system can be delivered | Develop collaboration tools for parking managers | Form partnerships with parking app providers | Provide clear line of site between investment and outcome |
| Understand how other departments can benefit | Obtain feedback on service from users | Launch live, integrated smart parking service to public | Feedback benefits to stakeholders | Document parking successes and gains |
| Understand learnings from other cities | | | | |

## SCOPE AND STRATEGY

Cities and parking service providers need to define their objectives before setting out to procure a smart parking service. The strategy and scope that the city or service provider adopts will dictate key decision points throughout the implementation and lifetime of the system.

Factors that will influence the strategy include the current issues and the desired changes and outcomes to be bought about in the parking environment and wider city. This will be influenced by the budget available, size of the deployment, and the role of the various stakeholders in the city.

Once a city has resolved all of these points, it can pull together a strategy and begin to build a list of requirements to go to market with. Critical to ensuring the success of this strategy is the commitment of all stakeholders across the value chain.

## PILOT

A small scale pilot is a good way to ensure that the processes that have been scoped around a smart parking service are fit for purpose, and that every stakeholder is clear of their role in the project. Amongst the deliverables that should be investigated at this stage are – Data security, data formats, network performance and installation processes. However a pilot should only been seen as a temporary measure, and the project should quickly move on to ensure time and energy are not wasted in over analysing all aspects of a service. The city or parking operator should also look to other cities who have implemented smart parking to gather lessons learned. Over time, as smart parking services mature, the pilot phase will likely become redundant as evidence of successful implementations emerges and smart parking implementations become more 'out of the box'.

## ESTABLISH

Once the pilot has been completed, cities should move quickly to establish a trusted system with incremental deliverables. It is best not to focus on all aspects of the service at once, but ensure that processes can come on line in an incremental fashion so that they can be perfected without impacting on rollout timescales. By phasing the approach, the city can increase confidence in the systems being deployed and ensure that citizens and stakeholders engage with and support the changes.

## SCALE

During the phased growth phase, the programme may still only be focussed on one site or one service. Once enough confidence has been gained in the system and the required processes have been proven to operate effectively in a live environment, the system can be scaled across multiple sites and open data APIs published to allow developers and other stakeholders to start building innovative solutions. At the point of scale, the city or parking operator can also start to introduce new concepts to drivers and citizens that smart parking allows such as dynamic tariffs or booking of parking spaces. Engagement with partners and citizens should continue, and new opportunities investigated as they arise. Partners such as mobile operators may be able to offer new scope to relationships such as use of brands and integrated services or apps.

## MATURITY

Once the smart parking service has been fully deployed, the city or parking operator should review performance and understand how the service is impacting citizen engagement and the cities longer term strategy to understand how to better manage the service and user demands. As technology drives change across the city, new services can be introduced and existing service re-configured to meet user expectations. The use of open standards will ensure that future changes can be more easily managed. KPIs will need to be used to ensure that the parking service continues to meet its objectives and mitigation undertaken if issues are identified.

# Conclusion

Smart parking can be enabled today by Mobile IoT from mobile operators. Mobile operators are strong, low risk, long term partners, well placed to meet all the needs of a smart parking service – Secure communications network and management platform, access to open data and integration of payment and billing systems. Mobile operators and Mobile IoT are also future proofed, as they are based on international standards with a roadmap towards integration with future networks and future smart cities needs. Mobile IoT also operates in licenced managed spectrum, so is a robust, scalable choice for all of a cities or parking operator needs.

Cities initiating smart parking investigations need to consider their mobile operator as a core partner and work alongside them to scope and implement smart parking. Mobile operators can share their experience of previous deployments, offer economies of scale and understand the intricacies of how to deploy in different environments. All parties in the value chain can benefit from having a mobile operator at the core of a programme, as the data generated can be controlled and managed throughout the value chain in a consistent, accessible and secure manner.

Smart parking offers a city or parking operator new ways to engage with the public and creates important secondary benefits including economic growth and reduced traffic and pollution. The business model behind smart parking is maturing now to a point where it is achievable, affordable and beneficial to a city. By ensuring that the cities strategy around communications, data and financing is robust, cities should move forward with their investigations and procurement of smart parking services.

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