IoT INVESTMENT CASE TOOLKIT

Smart Parking

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EXECUTIVE SUMMARY

The following document describes the Investment Case Toolkit method, the Toolkit. The Toolkit provides advice to enable city agencies to assess the value of an IoT-based project quickly without compromising rigour and to establish an evaluation process for IoT projects which is repeatable thereby benefitting future projects. It can be used at all stages of the project, including proof of concept pilots; retrofit to proof of concepts; scaling up pilots and large scale roll-outs.

Using Smart Parking management as an exemplar, this document shows how the Toolkit can be used by city council executives and others when appraising IoT projects in general and Smart Parking in particular.

When appraising an IoT intervention, the project team should recognise the new technology frontier being defined as the implications this will have for the business case are significant. Understanding why this is so is a subtle and important point and a valuable component of the Toolkit.

On one level the value of an urban Internet of Things derives from the optimisation of an individual business processes like smart waste or smart parking. This we call the direct benefit. In addition there may be indirect benefits. For example in the case of smart parking a reduction in the time it takes to find a parking space leads to a reduction in the number of vehicles on the road and by extension reductions in pollution levels and respiratory complaints. Additionally, by combining the data gathered from a number of different IoT interventions, and other data sources, like social media, maps, etc., inferences can be drawn which aid city executives, process managers and planners to design, build and operate a city which is sustainable. A sustainable city is one where population growth is uncoupled from resource consumption and where the quality of services rather than being compromised by this are improved. These are also indirect benefits. Accounting for direct and indirect benefits is crucial when it comes to building a positive business case for IoT.

Whilst appraising direct benefits is straightforward, due to the nascent nature of urban IoT indirect benefit evaluation is less so. First, few IoT interventions exist at a scale which will impact the agents of change that bring about indirect benefits. Consider the limited effect of a few hundred smart parking spaces upon the air quality levels of a city. Moreover, drawing a cause and effect relationship between the indirect benefit and the IoT is difficult. Any change may fall into the background noise of normal day to day variations. Again, consider measuring air quality and attributing any variation to a small scale IoT smart parking intervention. Second, IoT interventions which draw inferences by combining data from multiple sources are rare. Consequently, a mature understanding of the mechanisms of this type of indirect benefits does not exist and proper analysis of real world interventions to enable lessons to be learned and to be transferred to other projects has not yet been done.

Most current urban applications of IoT are a simple intervention. Smart parking or smart waste are good examples. Rather than IoT, these simple interventions are better described as Machine to Machine or M2M applications. In an M2M application a simple sensor will be monitoring some feature of an asset, like the fill level of a waste recycling bin. Analysis of the data gathered by the sensor data is used to improve a business process, for example to optimise a waste collection route. The final component in a simple M2M application is some form of actuator designed to use this information to effect a change. Often this is an application. In Smart Waste this would be an application developed to convey this information to the waste collection team.

City executives are looking to these simple M2M applications to reduce costs and optimise services, and this is understandable. However in the absence of a coherent urban IoT strategy as part of a larger Digital Strategy these initiatives are destined to become disparate islands of
technology unable to realise their full potential as enablers of an interconnected urban IoT network. Mindful of the present need to deliver services more efficiently and the longer term benefits of urban IoT to address the existential crisis of sustainable cities we advocate cities follow a plan of continuing M2M interventions whilst ensuring they are IoT ready. This theme underpins the Investment Case Toolkit.

IoT readiness we describe as an appropriate framework of policy which enables M2M type interventions to evolve into an urban IoT. There are four cornerstones of IoT readiness:

- Align the project with the wider strategic objectives of the authority, like citizen engagement, management of the environment, sustainability, etc.;
- Establish the project within a strong data management policy framework which ensures data integrity, protects an Individual's privacy and which provides storage which is secure; and,
- Understand the opportunity to effect transformational change upon existing business processes, like choice of funding, approach to procurement, etc.;
- Analyse the financial benefits in full, including indirect and long term benefits.

These principles have been adopted in the Toolkit. The toolkit is divided into three Phases, each with several tasks.

The first phase is concerned with understanding the context of the problem. This includes describing the service affected by the proposed project and understanding the problem being answered and the demand for a solution, not necessarily an IoT based solution. A key part of this phase is placing the project in the context of the overall strategic objectives and aspirations of the city authority. Informed opinion is obtained from the market and stakeholders regarding the possible solutions and the costs and benefits of the solution alternatives. SWOT analysis is used to summarise the project. It is important to communicate a description of the project and its objectives to both internal authority departments and to the wider public as early as possible in the project life cycle. Consequently the communications strategy is also deliberated upon in this Phase. The output of the first phase is a collection of considerations which together describe the context for the solution which will then be used in the following section, shaping the solution.

The second phase is about defining and refining the solution alternatives. The objective is to reduce the number of solutions down to two or three, (which can then be tested and compared in the final phase, the financial analysis). This second phase begins by listing a number of important design considerations peculiar to urban IoT which will help shape the design, commercial model and procurement process. In this phase the solution alternatives – by now a short-list – are compared to determine the costs – capex and opex and the benefits. Deciding how to measure success of the project and identifying costs associated with this is a further important point in this phase as is understanding risk. In a wider sense, this phase seeks to place the context in the context of other authority initiatives in order to maximise the benefits. An equality impact assessment, a legal requirement upon authorities, is also carried out in this section.

Taking the short list of solution alternatives and the costs and benefits of the various options, the third phase, Analyse the Finances, seeks to offer a numerical analysis of the costs and benefits (direct and where possible indirect) of the solution options. This includes a discussion of break-even analysis as related to an IoT intervention and approach to carrying out a sensitivity analysis and a discussion of lost opportunity costs.

Collectively, these three phases of work provide sufficient qualitative and quantitative analysis to thoroughly articulate the business case for a number of solution alternatives and to make recommendations on the preferred solution.
INTRODUCTION

This investment case toolkit for Smart Parking is part of the Future Cities Catapult contribution to the IoTUK programme. Launched as part of the Government’s £40m investment in IoT, the IoTUK programme is designed to advance the UK’s global leadership in IoT and increase the adoption of high quality IoT technologies and services throughout businesses and the public sector.

This document has been designed to support city council executives and others appraising Smart Parking projects which incorporate an Internet of Things (IoT). The advice offered follows the principles of the HM Treasury’s Green Book.

When searching for motivation to carry out appraisal, one can do far worse than look to Joe Grice, who, as Chief Economist and Director, Public Services to HM Treasury, in his preface to the Green Book, said:

“Appraisal done properly, is not rocket science but it is crucially important and needs to be carried out carefully. Decisions taken at the appraisal stage affect the whole life cycle of new policies, programmes and projects. Similarly, the proper evaluation of previous initiatives is essential in avoiding past mistakes and to enable us to learn from experience”.

When developing the Investment Case Toolkit for Smart Parking it was recognised that it should add to the offerings of the Green Book and specifically:

- acknowledge the new technology frontier being defined by IoT and advise upon the implications this will have for the business case;
- provide advice which enables agencies to assess the value of IoT quickly without compromising rigour; and,
- establish an evaluation process for IoT projects which is repeatable thereby benefitting future projects.

This latter point is crucial, for, in the not too distant future, the functionality delivered by the Internet of Things will be taken for granted as simply a component in the way we design, manage and deliver services in our cities.

Before we begin our discussion of an approach to appraising an IoT project, it would be useful to set the scene by reviewing what this thing is that we call an Internet of Things.
THE TOOLKIT

The toolkit provides a method to assess Internet of Things solutions. It assumes technology is part of the solution and is designed to be applied to proposed technology solutions rather than be used to define a solution to a problem such as unbalanced parking demand geographically and by time which contributes to circulating traffic searching for spaces.

Significant work has been done in the area of user led demand and design such as that undertaken by the Design Council (http://www.designcouncil.org.uk/our-services/service-transformation) and this should form part of the overall approach taken by local authorities. Whilst this toolkit takes a technology based approach, ensuring the technology solves a real problem, providing benefits for citizens and potentially making an impact against the root cause of the problem is part of the process.

In summary, agencies will find this toolkit enables them to:

- assess the return on investment from IoT smart technologies;
- evaluate an IoT initiative in weeks rather than months or even years; and,
- learn lessons and avoid making the same mistakes in future to capitalise upon benefits realised.

Whilst the example used here is Smart Parking, the tools and techniques can be equally applied to other IoT projects.

When to use the Toolkit?
The toolkit can be used at various stages of the likely roll-out of an IoT intervention: before delivery or to retrofit proof of concept deployments; after proof of concept has been carried out and in preparation for wide-scale rollout. This view was shared by local authorities. In early market testing asked local authorities to indicate when they may use the Toolkit. Feedback indicated (see Figure 1) that the tool would be useful at all stages of IoT technology roll out and specifically most popular at the pilot planning stage or before. In this case it

![Figure 1 – Feedback on when Local Authorities may use this Toolkit](image-url)
IoT Investment Case Toolkit

Smart Parking

would supplement existing processes undertaken to develop IoT business cases and deployments. Furthermore, early indications suggest that the tool could be used to replace planning stages and not just supplement existing stages specifically the planning stage for the proof of concept and the pilot planning stages.

An Outline of the Toolkit

The first phase is concerned with understanding the context of the problem. This includes describing the service affected by the proposed project and understanding the problem being answered and the demand for a solution, not necessarily an IoT based solution. A key part of this phase is placing the project in the context of the overall strategic objectives and aspirations of the city authority. Informed opinion is obtained from the market and stakeholders regarding the possible solutions and the costs and benefits of the solution alternatives. SWOT analysis is used to summarise the project. It is important to communicate a description of the project and its objectives to both internal authority departments and to the wider public as early as possible in the project life cycle. Consequently the communications strategy is also deliberated upon in this Phase. The output of the first phase is a collection of considerations which together describe the context for the solution which will then be used in the following section, shaping the solution.

The second phase is about defining and refining the solution alternatives. The objective is to reduce the number of solutions down to two or three, (which can then be tested and compared in the final Phase, the financial analysis). This second phase begins by listing a number of important design considerations peculiar to urban IoT which will help shape the design, commercial model and procurement process. In this phase the solution alternatives – by now a short-list – are compared to determine the costs – capex and opex and the benefits. Deciding how to measure success of the project and identifying costs associated with this is a further important point in this phase as is understanding risk. In a wider sense, this phase seeks to place the context in the context of other authority initiatives in order to maximise the benefits. An equality impact assessment, a legal requirement upon authorities is also carried out in this section.

Taking the short list of solution alternatives and the costs and benefits of the various options, the third phase, Analyse the Finances, seeks to offer a numerical analysis of the costs and benefits (direct and where possible indirect) of the solution options. This includes a discussion of break-even analysis as related to an IoT intervention and approach to carrying out a sensitivity analysis and a discussion of lost opportunity costs.
Defining IoT
What is an Internet of Things?
Before we begin discussing the approach to appraising the value of an urban Internet of Things which we recommend, it is worth reviewing what it is that defines an Internet of Things, particularly an Internet of Things in an urban context.

In the following, we first we describe a simple Smart Parking service which uses a machine to machine or M2M system and then show how this may be one of a multitude of similar M2M services. We then discuss how these separate M2M services might be drawn together using data analytics to form an Internet of Things. In this way we not only distinguish between a collection of M2M services and an Internet of Things but also give our definition of an Internet of Things.

In a simple M2M system (Figure 2), a device, usually a sensor and radio transceiver in a single unit, is attached to an asset to measure some quantity of interest. This measurement is then passed by a communications network, which may be wireless or fixed, to an application. The application provides a tool which enables the enterprise to monitor and control the asset based upon the measured information. Service enablement is a stage designed to free developers from needing to know the structure of the low level data. The overall objective of an M2M system like this is to optimise the business process.

Smart Parking is a practical example of an M2M system. Figure 3 shows a typical Smart Parking setup. A sensor and radio transceiver is embedded in the parking space. Whether or not the space

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Figure 2 – A simple M2M system

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Figure 3 – An idealised Smart Parking System
is occupied is measured by the sensor and this measurement is passed to an application running on a motorist’s mobile phone. Using the application, the driver can then find the nearest unused parking bay. Improved parking bay management, accurate record of parking space usage and reduced time to find an empty space are the immediate benefits.

In an Internet of Things, such an M2M application can be seen as one strand within a collective of similar M2M systems, see Figure 4. Here we see ‘spaces’ and a ‘transport’ application (highlighted in red) to indicate an M2M Smart Parking flow of information within an Internet of Things. Other sensors associated with people (electronic ticketing), vehicles (RFID payment tags), buildings (integrity monitoring sensors) etc., extend into the city similarly gathering data and feeding this back into the common data store. Context may be added to the data by accessing external databases, like social media, mapping and positioning, etc. An urban Internet of Things comes into its own when, using the sensor and context data a suite of applications is then able draw insights about the way the city is being used, the behaviour, activities and habits of its citizens and consumption of resources.

If properly managed this rich source of insight can be used to monitor and control the use of services and resources, to enrich, enlighten and augment the quality of life of citizens and to plan, design and manage sustainable cities. When applied to a city, IoT can enable sustainable growth without compromising upon the quality of the services enjoyed by the citizens.

In summary, an Internet of Things is far more than a collection of M2M systems and services. The hardware infrastructure of an Internet of Things is, however, made up of multiple, interconnected M2M systems. Indeed, interconnection between disparate M2M systems and data extraction are defining characteristics of an IoT. Appreciating that the science and techniques of data analytics can be applied to the data collection to draw inferences then gives a complete understanding of IoT (and differentiates between M2M and IoT).
PHASE 1: DEFINING THE CONTEXT

This phase, the first phase in the Investment Case Toolkit, is concerned with understanding the context of the problem. Throughout this toolkit we will illustrate key points using a problem which faces many Authorities, How do we manage parking more efficiently?

Whilst there are many potential solutions to this problem, we have assumed that the solution will be based upon a subset of IoT technologies; but even within this subset a multitude of options still exist. The overall aim of this section is to pare down this solution subset. The output should be a collection of considerations which together describe the context for the solution. The context will then be used in the following section – shaping the solution – to reduce all possible solutions down to a number of viable options.

Our work in this project has involved us engaging with cities who are actively developing their urban IoT. Throughout the course of our investigations, our suspicions that IoT interventions have the potential to influence the way that a city does business and affect a larger number of interested parties than a conventional service delivery project, were confirmed. To properly appraise an IoT project, the local authority should take into account this wider context. This means seeking the opinions and advice from a base much broader than one would in a conventional service delivery project. (A conventional service delivery project is one which does not use IoT as an enabler.) This means in addition to conventional demand analysis and a general description of the service and the problem, contextualising the project means aligning the project with the strategic objectives of the organisation; carrying out soft market testing; and, seeking commentary from a much broader stakeholder community.

The following is a discussion of our key learnings under these headings.

Task1.1 Describe the service
Describing the service is the first activity the project team should carry out. The objective should be to define the scope, scale and importance of the service. In the Smart Parking Management example this would include types of recycling bins, approximate distribution, etc., along with current collection, scheduling and disposal procedures. Additionally, at this point the stakeholder community – residents, businesses and others – should be described.

Task1.2 What is the demand?
It is necessary to identify the demand for the solution from a user point of view. Potential information sources may include:

- Parking service documentation
- Consumer and customer surveys
- Complaints
- Media commentary
- Vendor interviews and vendor product description and specifications
- Project sponsor
- Relevant previous/legacy projects

Practically, this would result in a problem statement and demand analysis typical of any conventional service delivery project.

Task1.3 Review the strategic objectives of the project
When it comes to building a comprehensive business case for an IoT project, aligning the strategic objectives of the project with the overall strategic objectives of the Authority is critical. Why this is so is one of the important differentiators between a conventional service delivery and IoT based service delivery project. This is a suble and important point worth discussing further.
An urban Internet of Things has the potential to be an enabler for service enrichment and planning rigour to an extent which previously was not possible. To illustrate this point, consider how the data gathered as part of an IoT intervention can be used. Of course optimising the service is the primary use of the data. In the case of parking management this means to provide a more efficient parking service. This is the direct benefit of the project. But indirect benefits may also be had. The data can be used as a source of revenue, sold on to other companies to develop new products. It can also be used by a community of developers, along with other data sources, see Figure 3, to provide additional services and benefits, previously unforeseen. These are some of the indirect benefits of the project. Collectively the direct and indirect benefits go to form the upside of the business case. Understanding and valuing the indirect benefits can be the point at which the business case tips from the red into the black, consider the Smart Parking example.

The primary motivation for Smart Parking most often comes from the council department concerned with parking services. Whilst the principle benefits to the department are likely to be cost reduction and general savings, it is important

<table>
<thead>
<tr>
<th>Potential benefit</th>
<th>Policy Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced emissions from vehicle traffic leading to a reduction in pollutants including NOx, CO, etc.</td>
<td>Environment</td>
</tr>
<tr>
<td>Reduction in motor traffic volumes from circulating traffic</td>
<td>Transport</td>
</tr>
<tr>
<td>Improving access to parking services through the provision of information on availability of spaces.</td>
<td>Parking Management</td>
</tr>
<tr>
<td>Moving demand away from over subscribed to lower occupancy locations leading to a more balanced distribution of parking</td>
<td>Parking Management</td>
</tr>
<tr>
<td>Improved payment compliance in paid for spaces – increasing revenues and reducing administration costs.</td>
<td>Parking Management</td>
</tr>
<tr>
<td>Operational efficiencies: the real time and historic sensor data provides a key source of information in the intelligent deployment of traffic wardens.</td>
<td>Parking Management</td>
</tr>
<tr>
<td>Improve access to parking bay occupancy data and other usage data</td>
<td>Digital Access and/or Transparency</td>
</tr>
<tr>
<td>Reduce demand for real estate by optimising usage of current parking space</td>
<td>Sustainability</td>
</tr>
<tr>
<td>Reduced time to park – improved customer experience and increased productivity</td>
<td>Economic Growth</td>
</tr>
<tr>
<td>Data is being increasingly used by external organisations and app developers in the production of integrated parking applications and in car solutions that will make finding a parking space even easier, and the payment transaction seamless.</td>
<td>Economic Growth</td>
</tr>
</tbody>
</table>
to look at the project as a means of delivering against the broader aspirations of the council. Smart Parking solutions can realise the following additional benefits which are likely to align strategically with your own Council’s strategies and policies, as defined in policy area:

It is envisaged that the information to identify alignment of the IoT Solution with the strategic objectives of the project will come from key sources including:

- Council Strategy documents
- Five year plans
- Manifesto and cabinet documentation
- National Policy Documents

**Task1.4**

**Test the market**

As IoT introduces technological ideas previously not known to the authority and disrupts existing processes and procedures, early market engagement is particularly important. The usual approach is through soft market testing to shape thinking on a number of issues that inform commercial strategies formed later on in the business case process.

A soft market testing exercise held with potential suppliers or investors allows informal exploration of procurement issues, new business models and technologies and helps form a strategy for approaching the market. It also offers the potential to invite council members or other executives to develop their understanding of the commercial opportunities and to develop an understanding of new IoT business models enabled and how they relate to conventional local authority and public sector approaches to procurement and contracting.

In particular, soft market testing provides the local authority with an opportunity to test its thinking around:

- the allocation of risk
- the limitations of current smart parking products and services
- where market participants see value being generated by the project
- The structure of the formal procurement process to ensure market interest
- An outcome framework to procurement to allow greater innovation from vendors in developing their solutions
- An outcome framework approach to allow interoperability of IoT solutions and a cross sector approach to incorporating IoT technologies, like smart parking, to be promoted.
- The time needed for product development or to develop specialist financing

Soft market testing should be used as early as possible in the project life cycle.

**Task1.5**

**Seek stakeholder opinion**

The costs, benefits and risks of the project should be discussed with the key stakeholders, and typically these would be:

- Head of parking services
- other cabinet members
- councillors
- other authorities (who have already carried out the intervention)
- executives at service provider
- pressure groups
- public opinion
- others as determined by strategic alignment

**Task1.6**

**Do a SWOT analysis**

Most authorities carry out SWOT (and associated PESTLE) analyses to develop their thinking on the project. In the case of IoT interventions, SWOT analysis can make a useful contribution.

SWOT analysis is typically used to identify the strengths, weaknesses, opportunities and threats of a proposed intervention. This is a critical initial step in framing a given project. It provides a useful opportunity to identify the key factors which may affect the outcome, both in the near and long term. In addition to the benefits or strengths of the proposition, SWOT analysis can be used to uncover follow-on opportunities, or indirect benefit. By now it is clear that the indirect benefits of an IoT project are important to developing a positive business case.

Whilst SWOT can also be used to summarise the important risks to a project by discussing the threats and weaknesses, PESTLE is a much more useful tool in this regard. Conventionally a PESTLE analysis is used to tease out the weaknesses and threats which then feed into a SWOT analysis. We suggest that when appraising an
IoT intervention. SWOT analysis should be used to summarise the strengths and opportunities of a project and add to the thinking about the benefits, direct and indirect. PESTLE analysis should be used to provoke thinking about the threats and weaknesses by looks to the wider political, economic, technological, social, legal and environmental prevailing conditions. By way of illustration, the effect of some expected fiscal policy on the project may be reviewed under the heading of Political; Economic may consider the local economy – can the services be afforded, and so on.

**Task 1.7**

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**Develop your communications strategy**

The final task in this section is about developing a strategy for communicating the project and its objectives to the wider community. An IoT intervention has the potential to be disruptive. To limit the potential disruption and confusion that such a project may bring about, it is important to communicate the purpose, the objectives and expected outcomes, especially if this is a trial, to those likely to be affected by it. In other words it is important to formulate a communications plan.

An IoT project has the potential for the motivation behind it to be misunderstood. For example, when a new smart parking management systems is introduced, there may be a perception that the information is being used to increase parking charges. This is not uncommon in data gathering and IoT type projects. In this sense the communications plan is the first steps in a journey of education.

The overall aim of the plan is to set out a framework that defines how the project and its benefits will be communicated to all interested and affected parties. Interested and affected parties are not limited to residents and businesses. There is also a need for communicating the nature of the project to stakeholders within the council – council officers, councillors and others, for example suppliers of existing services. Whilst the focus of the external plan is about defining the approach to communicating awareness to the user; informing the user of availability of the service and should be ongoing throughout the lifetime of the service, the internal approach should have a slightly different focus, in particular this should include creating awareness of project, how the data is to be used and highlighting potential connections with other IoT projects and Authority initiatives in general.
PHASE 2
SHAPING THE SOLUTION

As implied in the title, ‘Shaping the solution’, this phase is about defining and refining the solution alternatives. The objective is to reduce the number of solutions down to two or three, which can then be tested and compared with the do-nothing case in the final Phase, The financial analysis.

First we discuss some important design considerations which are peculiar to an IoT intervention. Taking on board the comments will take us a long way towards shaping the final solution. At the conclusion of this task we imagine the Authority will have sufficient information from the work carried out so far to arrive at a short list of solution alternatives. The next task is to test these against other works going on within the Authority to find opportunities to optimise the benefits whilst minimising the risks. The final task in this phase is to compare the solution alternatives in terms of benefits, risks, process impacts and value chain impacts.

At the conclusion of this phase, all evidence needed for the business case will have been gathered, and along with the Financial Analysis, Phase 3, the project team will be in a good position to write a compelling business case.

Task 2.1
Important design considerations for key components

Standard business case evaluations normally include assessment of the direct value of the project, or as termed in this report, an M2M implementation. However, IoT enables additional benefits to be created which are not always accounted for in the traditional business case approach. This section seeks to illustrate some core examples of these benefits and why they should be included in the business case assessment. The wider implications enabled by IoT and presented in this document are:

- Sensors Networks
- Network Connectivity
- Improved Data Analytics
- Open Data Standards
- Data Visualisations
- Integrated Data Analytics
- Open Data as an Asset
- The Deployment Scale

Sensor Networks and Network Connectivity

It is good practice to deploy standardised technologies. Standards lead to economies of scale which drives down costs. Standardisation of technologies leads to interoperability between the devices and ease of interchangeability of devices. This enables the city to engage with multiple vendors during the lifetime of a project and prevents vendor ‘tie-in’ at the conclusion of a project. These are important commercial considerations when it comes to developing an Internet of Things which uses multiple, competing vendor offerings.

The IoT radio access network as shown in Figure 5 is particularly troublesome when it comes to standards. The standards world relating to the radio access network is confusing and fragmented. To secure a commercial foothold in the marketplace, many companies are advocating their own inventions as de facto, or informal standards. Broadly a taxonomy for this emerging
landscape can be described along spectrum and proprietary lines. Unlicensed spectrum (Wi-Fi) has the virtue of being free. An open standard has the advantage of being publicly available without the need for a licence. Both unlicensed spectrum and open standards will materially contribute to a positive business case and attract new entrants. However, new entrants due to cash constraints often have the greatest risk of failure. This fact should be foremost in the mind of an authority when investing in a radio access solution. In contrast, closed standards and standards which use licensed spectrum tend to be supported by the big players in the market. Whilst, these companies are less at risk of failing, an IoT solution founded upon a closed standard, arguably limits the authority’s ability to integrate multiple proprietary solutions and to choose an alternative solution at the end of a contract. This is particularly problematic in the IoT world, where data is gathered from multiple sources and in a nascent market where new solutions are emerging almost daily.

Two important components of the IoT infrastructure are the sensor and the modem. The sensor is a transducer attached to the asset to measure some particular feature. In the case of smart parking this would typically be infrared or ultrasonic sonar technology to detect when a vehicle is parked in the bay. The modem is the transmitter and receiver pair which communicate the data back and forth between the sensor and the main communications network, a fixed or mobile network as appropriate. The means by which these components of an IoT infrastructure are interconnected, is an important consideration. If the sensor and the modem are bought from different manufacturers, great care must be taken to ensure that these two devices communicate with one another, which means they both must adhere to a common design for the interface between them. The modem should adopt standards which enable it to communicate with the fixed or mobile network. For example a 3GPP standard, like GSM for wireless communications or Ethernet for wired connections.

Interoperability and standardisation challenges are not limited to the access network, they are problematic in the communications network too. The very nature of an Internet of Things in a city means that wireless connectivity will be key to its delivery. The vast majority of sensors will be connected into the core network via wireless connections, and this means wireless mobile networks – the same networks used by mobile phones. Cities must be prepared to pay to access the mobile network at a price which competes with other mobile services like mobile broadband. That is not to say that the price of connecting a sensor is the same as a mobile device, but it does mean that the business case for an IoT network must be strong enough for a city to compete with other services when bidding for wireless connectivity. An authority will need to assess all the benefits – including indirect and long-term – that a project has to offer. Wi-Fi is an alternative to mobile network

![IoT access network showing multiple sensors, a single access point. Also shown is cloud connectivity and a data server](image-url)
connectivity. And in that regard, some comments provide useful food for thought here. Wi-Fi connections are subject to interference, particularly in areas of dense population. This may limit the reliability of communications. Wi-Fi relies upon street furniture to anchor the antenna systems and a source of mains electricity. It may be difficult to find a location with the appropriate utilities. Many cities have sold off the rights to Wi-Fi on street furniture to commercial Wi-Fi providers. Which exacerbates the problem of finding the appropriate site. Unless Wi-Fi is being provided by a third party, it is not possible to protect the communications quality of service using service level agreements. So a proper due diligence exercise will need to be undertaken to assess the feasibility of Wi-Fi network connectivity. This may include network speed and capacity (bandwidth) analysis.

As a corollary, Authorities should consider the implications of selling off the rights to access street furniture, effectively selling off the rights to Wi-Fi, as ready access to Wi-Fi connectivity will become an important contributor to positive IoT business cases. This will become increasingly important as the dramatic growth of IoT based services in cities is realised.

Open Data Standards
Interoperability at a sensor and network level should be developed further by looking at embedding data standards for data interoperability.

One leading example of this is the Hypercat (www.hypercat.io) standard which is a hypermedia catalogue format designed for exposing information about the Internet of Things assets over the web. It is an open, JSON-based hypermedia catalogue format for exposing collections of uniform resource identifiers (URLs) for exposing information about IoT assets over the web.

As a catapult we are breaking new ground in this area. We are developing a tool to allow cities to benchmark themselves (or be benchmarked) against the PAS 182 standard. PAS 182 is concerned with interoperability and establishing a data model of interoperability between the different 'data gathering' systems.

Data Visualisation
The use of the data and/or visualising it in real-time or near real-time to improve decision making and therefore operational efficiencies is considered to be a key feature of a smart parking service. The feature in this example contributes to a clear benefit by making the management of the service easier.

The example shown illustrates that on a geographic level, in 2014 the sensor zone had several highly occupied streets (red icons), with some adjoining under occupied streets (green icons), suggesting local imbalance of demand. By 2015, most of the dark red streets had converted to less decisive colours, with almost no red/green pairs, suggesting a better spread of occupancy between nearby streets.

Figure 6 – Visualisation of parking occupancy in Westminster for 2014 and 2015
Data Analytics

“Successful smart cities invest in open, flexible, integrated and scalable ICT architectures that enable accelerated service innovation such as provision of automated and real-time dynamic response capabilities.”

There are numerous benefits which improved data analytics reusing the data collected and made available can offer including:

- Local Authority Benefits – Improved Decision Making, Efficiency, Cost Savings, Improved Partnership Working and Better Outcomes
- Citizen / Communities Benefits - Improved learning, health and employment as a result of better support through better access to preventative measures
- Business / Local Economy Benefits - Better market insight for the retail economy, improved strategic investment planning during regeneration projects

These elements can all be included from a qualitative viewpoint. The value of the analytics is improved as more data becomes available for reuse and the software tools and skills are in place to undertake the analysis. The availability of IoT data can support the business case for integrated data analytics and vice versa.

The business case benefit of integrated data analytics can be further enhanced by ensuring open data standards are put in place.

Open Data

The UK Government and the devolved administrations are promoting the provision of Open Data:

- making it easier to access public data
- making it easier for data publishers to release data in standardised, open formats
- engraining a ‘presumption to publish’ unless there are clear, specific reasons (such as privacy or national security) not to do so

The often real-time and data rich nature of IoT interventions can provide a valuable asset and specifically a public asset which can be included in any business case development. Open Data benefits can be identified for key user groups including but not limited to:

- The Council in improving transparency and accountability
- The general public in accessing public data
- The private sector with better informed business decisions
- The private sector through the creation of services using data as an asset
- Academic Institutions in having greater access to data for research

<table>
<thead>
<tr>
<th>Date</th>
<th>Study Lead</th>
<th>Scope</th>
<th>Benefit of open data (% GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>EU Commission (2)</td>
<td>Europe (public sector data only)</td>
<td>0.5</td>
</tr>
<tr>
<td>2013</td>
<td>Shakespeare (3)</td>
<td>UK (public sector data only)</td>
<td>0.4</td>
</tr>
<tr>
<td>2013</td>
<td>McKinsey (4)</td>
<td>Global</td>
<td>1.1</td>
</tr>
<tr>
<td>2014</td>
<td>Lateral Economics (5)</td>
<td>G20 countries</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Table 1 – The impact of open data on GDP

1 http://www.scottishcities.org/s/Smart-Cities-Readiness-Assessment-Guidance-Note.pdf
2 http://www.europeandataportal.eu/sites/default/files/edp_creating_value_through_open_data_0.pdf
Quantifiable research indicates that the positive impact of Open Data on GDP can be anywhere between 0.4% and 4.1%. The EU Commission report indicates that Open Data can contribute directly to €262 Million of cost savings for the public sector. The figure is a direct calculation from a Danish Government survey that indicated a cost saving of 0.22% between 2010 and 2014 directly attributed to open data.

To ensure this is taken into account the Contracting authority should consider appropriate data ownership, data provision through Application Programming Interfaces and compliance with standards in their Contracts.

**Task 2.2**

**Consider the solution alternatives**

At this point, the authority, along with commercial partners, should be able to define a shortlist of solutions which have the right sensors, appropriate network connectivity and make maximum, appropriate use of the data gathered. There may be solution alternatives with respect to the business model used. As a simple example the comparison below for smart parking compares a self-build solution with a more outsourced turnkey or build to order solution.

Identifying the main fixed and running costs of the solutions is one of the key outcomes from this task. The costs considered are primary capital expenditure (CAPEX) and operational costs (OPEX). Additional costs like the cost of retraining, process re-engineering, change management etc. are considered later in this document in Phase 3.

**The self-build sensor solution**

Self-build describes the situation where a council decides to build, own and operate the service and the infrastructure needed to deliver the service. In the case of a real time parking monitoring solution this would typically mean procuring sensors, installing them, provisioning connectivity to a centralised database and designing the analytics and the application used to plan collection routes.

<table>
<thead>
<tr>
<th>A general description of the cost item</th>
<th>Capex</th>
<th>Opex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensors</td>
<td>Cost of sensor</td>
<td>Regularly testing</td>
</tr>
<tr>
<td></td>
<td>Replacement</td>
<td></td>
</tr>
<tr>
<td>Network communications</td>
<td>Purchase of network hubs - e.g. Wi-Fi</td>
<td>Fees to network providers, mobile or fixed operators</td>
</tr>
<tr>
<td>Database(s)</td>
<td>Purchase and installation of database equipment</td>
<td>Service charge of network cloud – database as a service</td>
</tr>
<tr>
<td>Data processing</td>
<td></td>
<td>Data analysis as a service</td>
</tr>
<tr>
<td>Application</td>
<td>Cost of developing app</td>
<td></td>
</tr>
<tr>
<td>Data access</td>
<td>Data devices</td>
<td>Connectivity costs – network service charges</td>
</tr>
<tr>
<td>Managing data</td>
<td>Security software</td>
<td>Policing data access</td>
</tr>
</tbody>
</table>

*Table 2 – The self-build sensor solution*
A turnkey or build to order solution
A turnkey or build to order solution involves the authority engaging with a commercial entity to provide the service. Under contract with the council the service provider builds and owns the infrastructure and operates the service. If this is an off the shelf solution then typically this is called a turnkey solution. If the service requirements dictate a bespoke infrastructure, then this is called a ‘build to order’ solution.

The principle implementation costs is repeated operational expenditure through fees paid to system integrator and operational expenditure to service provider, which may be the same company or two different organisations, as discussed.

Task 2.3
Compare the merits and limitations of the solutions
The following is a list of the main qualitative considerations when comparing a self-build and a turnkey solution. These may point towards further costs, benefits and risks.

The self-build sensor solution
- Identification and replacement/repair of failing parts is straightforward
- No need for contractual Service Level Agreements to manage service quality
- The value of the service is retained within the council
- The council is not ‘tied-in’ to a single service provider – can change providers of service elements, e.g. sensors, at will
- Solution knowledge remains within the council
- The council is not tied into long term contracts
- Retaining control of data – maximising use of data, e.g. making it available to an app community or for service provision in house
- The council can control privacy and security of data
- A turnkey or build to order solution
- Predictable running costs
- Contract obligation for service provision
- Good-fit with the trend to service outsourcing
- Leverages service provider expertise, e.g. data management
- Responsibility for data management outsourced – minimising risk of reputational damage
Task 2.4  
Consider how to prove success

The performance of the project must be assessed post implementation. The mechanism for measurement will need to be accounted for in the business case. Measuring the performance of the intervention is required to determine whether benefits have been realised. Any mechanism for measuring performance will contribute to costs.

The principle means of measuring performance will be to compare ‘before and after’ effects upon the benefits, listed in NBED #. The rationale being that collectively these measure the success of the project. Provision should be made at the outset of the project to measure the following as a baseline before the project commences and at regular intervals throughout the project. If the project is a pilot scheme then a concluding measurement should be made at the end of the trial period.

- **Baseline the Data.** Here we should carry out market analysis using the data sources to establish the baseline of social, economic and environmental metrics against which the evaluation of improvement will be made.
- **Measure Performance.** Improvement in these metrics is expected as a consequence of the IoT interventions. These improvements will be recorded and formatted suitable for analysis.
- **Quantify Performance.** Using an analytical process, like the Performance in Use analytical tools developed by Future Cities Catapult, the improvements will be quantified.
- **Optimise Performance.** It is also possible to consider optimisation at this point to determine improvements to the intervention parameters. An improvement is one which brings about an increase in the measured benefit(s). Future Cities Catapult has developed such an Optimisations Tool as part of its Performance in Use portfolio.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes to bay designations</td>
<td>How bay designations change and whether they now better match customer needs will be an important proof of concept metric.</td>
</tr>
<tr>
<td>Bay occupancy rates:</td>
<td>Bay occupancy levels will be noted throughout the course of the trial and from this changes in the year on year demand differential for bay spaces and parking real estate and cost differential in the delivery of parking service core functions should be assessed.</td>
</tr>
<tr>
<td>Service enquiries from the public</td>
<td>The impact upon enquiries, i.e. service complaints or members enquiry received outside of the statutory appeals process: issuing of notices / appeals, CEO behaviour, Suspensions should be noted.</td>
</tr>
<tr>
<td>Penalty Charge Notifications</td>
<td>The number of PCNs issues should be monitored and compared with the numbers issued before the intervention.</td>
</tr>
<tr>
<td>User survey results</td>
<td>Additionally, councils should consider carrying out a user (residents, workers and businesses) survey to feedback customer/user evidence.</td>
</tr>
<tr>
<td>Improving air quality</td>
<td>Reduction vehicle emissions improve air quality, mitigate climate change and contribute to making a ‘low carbon and low waste city. To do this baseline measurements of air quality need to be made. This may mean another IoT project. NBED Performance in Use?</td>
</tr>
</tbody>
</table>

Table 3 - A list of the benefits and metrics which might be measured to prove the success of a Parking management intervention
Task 2.5
Testing the solution against other Authority activities

The candidate solutions should now be tested against the following considerations to develop further any benefits and to identify and mitigate some of the risks:

- The impact of scale upon the likely success of the proposed solutions
- The impact of the proposed solutions upon existing processes and value chains
- Considering the solutions in the broader IoT context within the authority
- Considering the solutions against a backdrop of other Authority projects

The objective of this task is to identify any additional benefits or risks of the proposed solutions. Additional when one views the project against a backdrop of other Authority activities.

The impact of scale

IoT technologies and deployments often benefit from deployments at scale. The scale itself of the project can therefore be a key supporting driver of the roll-out of IoT and contribute to the business case.

The smart parking example lends itself to deploying at scale across the area as the benefits within monitored areas have been shown to be positive when compared with the unmonitored zones. Furthermore evidence suggests that the monitored zones have the potential to improve demand to the detriment of the unmonitored zones as users feel more confident parking in a zone with a known space over that with unknown parking levels.

Furthermore the economies of a wider roll-out of IoT also contribute positively to the business case, and specifically can offer a better return on:

- Network Connectivity
- Data storage
- Data Management
- Data analytics and Dashboards
- Data alerting services
- Application development and Deployment

Impact upon existing processes

To fully cost the impact of the intervention upon council services it will be necessary to identify the processes affected by the project. The following is a list of likely processes affected by smart parking; also shown is the impact upon the associated processes, and identification of the principal costs.

<table>
<thead>
<tr>
<th>Process</th>
<th>Impact</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking enforcement</td>
<td>Process for dynamic response to compliance failure will be required.</td>
<td>retraining, reorganisation, change management and process reengineering</td>
</tr>
<tr>
<td></td>
<td>Human resource savings.</td>
<td></td>
</tr>
<tr>
<td>Communications and PR</td>
<td>Data will be available and used by communications officers working on preparing correspondence with members of the public Advice on relevant data trends.</td>
<td>change management and process reengineering</td>
</tr>
<tr>
<td>Engineering Services</td>
<td>Need to be advised of the location of sensors and arrange for reinstatement of sensors after works. Process for sensor removal should be established.</td>
<td>Training, change management and process reengineering</td>
</tr>
<tr>
<td>Bay sensor smart parking vendor</td>
<td>Service delivery process should be established.</td>
<td>change management and process engineering</td>
</tr>
<tr>
<td>Transport strategy</td>
<td>Inform any relevant policies</td>
<td>change management</td>
</tr>
</tbody>
</table>

Table 4 – The impact on existing processes
Impact upon existing value chains

An IoT project has the potential to disrupt the value chain and it is important to investigate to what extent this is true for each solution. Whilst value chain disruption can be managed, the lesser disruption can point to the preferred solution.

A value chain diagram illustrates the flow of cash between stakeholders in return for the provision of a service. A simple value chain is shown below.

Value chain analysis is a useful technique in the process of identifying how an Authority can benefit from a new technology. This will show current cash flow, and how this might change and importantly diverge from a reciprocal service flow if the proposed technology is adopted. Comparing current and future value chains contributes to the appraisal in a number of important ways, if:

- serves to identify the business process under consideration, putting it under the microscope and separating it from the noise of other processes;
- helps to identify the commercial entities in the process and thereby to identify the key personnel for subsequent stakeholder-interview;
- indicates areas where service level agreements need to be introduced to ensure that the benefits of the technology are seen by those paying for it;
- provides valuable information for the benefit-cost analysis stage to come later.

How these insights are derived from an analysis of the value chain is best illustrated with a practical case, for example Parking Management. Here, below, we can see a simplified value chain of a typical parking management process. Cash and services are exchanged between the local community and the local authority in the form of taxes and parking charges, respectively. Similarly, cash and services are exchanged between the service provider and the local authority; the local authority pays the service provider to deliver parking management.

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- provides valuable information for the benefit-cost analysis stage to come later.

Improvements to the process of parking management might be enabled by the IoT system monitoring the status of the sensors deployed, for example timely information about parking availability.

Here, below, we can see the local authority has decided to fund the introduction of an IoT system. The authority could have chosen to self-manage the project, including the procurement of software, hardware and associated services as well as overseeing the process of integration. In this case the authority has chosen to hand over the responsibility for design, procurement and integration to a systems integration company. The integrator in turn has engaged software and hardware equipment vendors to install the infrastructure.
Contrasting the exchange of cash and services before and after the introduction of an IoT system shows change. In this example it can be seen that cash flows to the system integrator, but arguably there is little change in the service offered to the authority compared with before the intervention. The value chain could be rebalanced by service level agreements – to improve the quality of the service. Additionally the diagram shows the potential for the benefits – timely alerts etc., to reduce the costs of the service provider. Again the value chain can be rebalanced by creating contractual obligations to pass on part of these benefits and to share ownership of the data with the council.

Whilst a fairly simple example, it nevertheless shows how value chain analysis can be used to understand how the project may disrupt existing cash and reciprocal service flows and where SLAs may be needed to ‘balance the chain’.

**Place in the context of other IoT projects**

An understanding of the opportunities for additional benefits and costs may come from placing the project in the context of other IoT projects. The true benefit of IoT will be realised through the combination of a number of IoT projects. It is important therefore to understand the relationship between the project under consideration and synergies (costs and benefits) from related IoT projects. The following questions should be answered:

- Is the project an anchor project for a programme of IoT interventions?
- Does the project fit into a programme of IoT interventions?
- Is the project an upscaling of a previous project?
- Can lessons learned from this project be transferred to other IoT projects?
- Describe how the project can be modularised (to make it scalable and replicable).

**Place in the context of other authority projects**

Understanding the opportunities for additional benefits and costs may come from placing the project in the context of other authority initiatives. It is important to understand how the project fits into a wider scheme of council projects. This may reveal opportunities to achieve efficiencies and reduce costs, especially in management and engineering works, for example, reduce delivery time, reduce cost and materials by avoiding duplication of work, avoiding redoing work, and by combining similar works into one. The following questions should be considered:

- What engineering works are taking place in the area where the pilot is designed to take place?
- Will these works effect the deployment of sensors and related communications equipment?
- Are there opportunities to avoid duplication – for example in road excavation?
- Inform internal communication
Task 2.6
Risk Assessment
The analysis of risk drives many aspects of investment decision-making for public and private investors and authorities. It is therefore crucial to understand the nature of risks as they affect an urban IoT project and how these risks differ from those which traditional propositions face. Five stages to consider, illustrated by Smart Parking examples, are outlined below:

- Risk identification: the process of identifying all the risks relevant to the project, whether during its construction phase or its operational phase;
- Risk assessment: determining the likelihood of identified risks materialising and the magnitude of their consequences if they do materialise;
- Risk allocation: allocating responsibility for dealing with the consequences of each risk to one of the parties to the contract, or agreeing to deal with the risk through a specified mechanism which may involve sharing the risk;
- Risk mitigation: attempting to reduce the likelihood of the risk occurring and the degree of its consequences for the risk-taker; and
- Risk monitoring and review: monitoring and reviewing identified risks and managing new risks as the smart parking project develops and its environment changes. This process continues during the life of the contract. The following risks tend to be particularly relevant to urban IoT projects and should feature in discussions with suppliers or as part of market engagement processes.

When it comes to risk, several good templates and tools exist to nudge our thinking in the right direction. One of the best known is PESTLE, which seeks to frame our thinking about risks in terms of Political, Economic, Societal, Technological, Legal and Environmental contexts. Our approach however has been to consider risk under the following headings, which we feel are more relevant to an urban IoT intervention:

- Finance
- Politics
- Technology
- Operations
- Management
- Behaviour change
- Revenue and demand, and
- New combinations of risk.

Finance risk
- For local authorities who are not running an operational surplus in their parking management and enforcement there are few finance sources available to fund the substantial upfront investment required into new and often unproven IoT technologies at the scale required to achieve operational efficiencies. Smart parking models tend to focus on using IoT technologies unlock efficiencies in the of the parking estate through improved utilisation and enforcement.
- If loan financing is sought through an organisation such as the Public Works Loan Board, there are few examples of large scale deployments of smart parking projects achieving the direct financial efficiencies at the organisational level required to fund the loan repayments. In other words, the lack of comparative evidence of efficiency savings from other successful projects presents a huge risk from a finance perspective.

Political risk
- There is a significant political risk with smart parking schemes due to the large numbers of third parties making use of a scheme to park and the wider effects that parking policies have on business such as retail and the operations of public facilities such as hospitals. The large number of diverse stakeholders affected by changes often encourages press interest which will tend to focus on the negative effects of a smart parking scheme.
- Any negative operational issues picked up by the press will affect the appetite for expanding the smart parking scheme and potentially future smart city initiatives using ICT in the urban environment.

Technology risk
- A smart parking scheme may be overtaken by new mobility technologies reducing forecasts revenue.
- The collection of data about individual’s movements on a granular scale by a council and 3rd party raises cybersecurity and privacy risks.
Operational risk
• Smart parking schemes involve the deployment of ICT in the urban environment which may become susceptible to connectivity outages and equipment and power failures.

Management risk
• Managing a smart parking contract or in-house scheme may require different skills, knowledge and management to current practice.

Behaviour Change, Revenue and Demand Risk
• In areas with competing parking options available there may be a perception from consumers that smart parking schemes are complex to use and existing parking options are more attractive. The business models for smart parking tend to rely on efficiency savings from greater utilisation, more efficient payment process and enforcement to provide a revenue stream to help fund the project. As such, any fall in occupation rates of parking spaces below the baseline agreed at the start of project would have a significant negative impact on the business plan for a scheme.

New combinations of risk
• Smart Parking projects introduce a significant new ICT component to the parking management sector and local authority contracts. From a procurement perspective this introduces the risks associated with carrying out successful ICT projects in addition to delivering an effective parking service. Those risks are currently managed by different people, and in a different way in local authority and may require a significant investment of time and resources to set up new procurement and contact management processes. Corporate leadership in a local authority is therefore essential with an executive and political sponsor appointed to help provide leadership and steer the project through implementation and delivery stages.

The allocation of risk will have an impact the market appetite for participating and the ability of vendors to raise finance.

Some of these risks may be unfamiliar to local authorities and require technical assistance to appraise and develop mitigation strategies and understand their impact upon the viability or the expected social or environmental return of the scheme.

In general, the private sector is better placed to assume commercial risks while the public sector is better placed to assume legal and political risks.

Task 2.7

Equality Impact Assessment
“An equality impact assessment is a tool that helps public authorities make sure their policies, and the ways they carry out their functions, do what they are intended to do and for everybody. Carrying out an EIA involves systematically assessing the likely (or actual) effects of policies on people in respect of disability, gender, including gender identity, and racial equality and, where you choose, wider equality areas.”

This requires consideration specifically when looking at the direct impact of technology on the user groups such as staff or the general public. Previous examples of public sector equality impact assessments on technology projects indicate for example:

• that “Some members of staff and customers may have difficulties adapting to new technology and ways of working” with risk mitigation through appropriate training; and
• that confirmation should be made that technology is to be DDA compliant and accessible (Disability Discrimination Act).

The Authority has a legal obligation to carry out an EIA. IoT projects have the potential to benefit, and these benefits should be equally seen by all citizens, regardless of disability, gender, gender identity, race, and, where appropriate, wider equality areas.
PHASE 3
FINANCIAL ANALYSIS

Whilst the analysis of Phases 1 and 2 frames the project in a qualitative fashion, the business case needs an additional, numerical measure of the project’s ‘value’ to the authority. In this a Cost Benefit Analysis approach can be very useful.

Before moving on to discuss quantitative analysis in detail an important observation on qualitative analysis is required. Most public sector services are not designed to make a profit. Unlike a commercial business case therefore, qualitative analysis carries a great deal of weight and should be properly articulated in a public sector business case.

Cost Benefit Analysis is a systematic way of assessing a project quantitatively. Not only does this provide a ‘Figure of Merit’ for the project, it also enables a straightforward, numerical comparison between alternative-option projects.

Crucial to being able to properly value a project are the time taken to see the benefits and the risks. Cost Benefit Analysis also can be used to model the impact of time upon the project and to evaluate uncertainty and risk.

Cost Benefit Analysis evaluates the project based on its net benefits: total benefits less costs. The impact of the costs and benefits upon the project are appraised using Break Even Analysis while a separate Sensitivity Analysis should be used to analyse uncertainty. Uncertainty can also be modelled in the Break Even Analysis.

Task 3.1
The Break Even Analysis
Break Even Analysis endeavours to understand the point at which the project costs, set up costs and running costs, are matched by the benefits of the project, i.e. the Break Even Point. The first stage in estimating the break-even point is to determine the contribution margin.

Typically when applied to parking management the contribution margin is measured by improved efficiency, numerically this is the difference between the additional revenue per unit and the direct costs* to deliver the service per unit. So if the Revenue is £500 per day and the Direct Costs are £40 per day, the contribution margin is £460 per day.

![Contribution Margin](image)

\[ \text{Contribution Margin} = \text{Revenue per unit} - \text{DCI} \]

*DCPU: Direct Cost per Unit - expenses which can be traced directly to a cost centre or product

**Note (1)** It is important to note that compared with costs and revenues prior to the intervention, costs can fall and revenues can increase giving a double benefit.

**Note (2)** In the case of a new service costs will increase as a direct consequence of the intervention,

**Note (3)** Additional benefits may be seen in other areas, like health, it is important to endeavour to value these additional benefits.

Knowing the contribution margin, all that is now needed to determine the break-even point is to determine the number of days over which the service must be delivered (i.e. duration of cost efficiency delivery) to meet the cost to set up the project, to break even. This is achieved by simply dividing the savings per unit into the total overhead costs.
So, if, as in our example, the overhead costs of the project is £100 000, then, the project will break even during the eight month of operation, £100 000 ÷ £460 (per day).

To help in this process of identifying and categorising costs, it is useful to first assemble costs in CAPEX and OPEX tables, Table 5 and Table 6. CAPEX (capital expenditure) is a one-time expense, usually to set up the project and its infrastructure; OPEX (operational expenditure) describes the costs associated with running the project.

Often the CAPEX costs will be the fixed, overhead, project costs and OPEX will make up the running costs, the costs to deliver the service. However apportioning fixed and variable costs in this way should be done with care and advice from finance departments should be sought where necessary.

Examples of CAPEX and OPEX tables for a typical intelligent parking project can be found in Table 5 – CAPEX and Table 6 – OPEX.

<table>
<thead>
<tr>
<th><strong>CapEx Estimates</strong></th>
<th><strong>Estimated starting Capex</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infrastructure</strong></td>
<td></td>
</tr>
<tr>
<td>Parking Sensors</td>
<td></td>
</tr>
<tr>
<td>Number of Parking Sensors</td>
<td>3000</td>
</tr>
<tr>
<td>Cost per Sensor</td>
<td>£150</td>
</tr>
<tr>
<td>Installation Cost per sensor</td>
<td>£50</td>
</tr>
<tr>
<td>Total Cost of Sensors</td>
<td><strong>£600,000</strong></td>
</tr>
<tr>
<td>Warden Devices</td>
<td></td>
</tr>
<tr>
<td>Number of Warden Devices</td>
<td>100</td>
</tr>
<tr>
<td>Cost per Device</td>
<td>£100</td>
</tr>
<tr>
<td>Total Cost of Sensors</td>
<td><strong>£10,000</strong></td>
</tr>
<tr>
<td>Realisation</td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td><strong>£10,000</strong></td>
</tr>
<tr>
<td>Applications</td>
<td></td>
</tr>
<tr>
<td>Number of Applications</td>
<td>1</td>
</tr>
<tr>
<td>Cost Per Application</td>
<td>FREE</td>
</tr>
<tr>
<td>Total Cost of Applications</td>
<td><strong>FREE</strong></td>
</tr>
<tr>
<td>Human Capital</td>
<td></td>
</tr>
<tr>
<td>Number of Specialists</td>
<td>3</td>
</tr>
<tr>
<td>Cost Per Specialist</td>
<td>10,000</td>
</tr>
<tr>
<td>Total Cost of Specialists</td>
<td><strong>30,000</strong></td>
</tr>
<tr>
<td>TOTAL ESTIMATED CAPEX</td>
<td><strong>£650,000.00</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>OPEX Estimates</strong></th>
<th><strong>Estimated Yearly Cost</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infrastructure</strong></td>
<td></td>
</tr>
<tr>
<td>Sensors</td>
<td></td>
</tr>
<tr>
<td>Number of Sensors</td>
<td>3000</td>
</tr>
<tr>
<td>Operating cost per Sensor (per month)</td>
<td>£30</td>
</tr>
<tr>
<td><strong>£90,000</strong></td>
<td></td>
</tr>
<tr>
<td>Warden Devices</td>
<td></td>
</tr>
<tr>
<td>Number of Warden Devices</td>
<td>100</td>
</tr>
<tr>
<td>Operating cost per device (per month)</td>
<td>10</td>
</tr>
<tr>
<td><strong>£12,000</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Estimated Fixed Operating Cost of Sensors</strong></td>
<td></td>
</tr>
<tr>
<td>Sensor Connectivity</td>
<td></td>
</tr>
<tr>
<td>Number of Sensors to be connected</td>
<td>3000</td>
</tr>
<tr>
<td>Operating Cost per Connected Sensor (per month)</td>
<td>£0.20</td>
</tr>
<tr>
<td><strong>£7,200</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Yearly Estimated Cost of Connectivity</strong></td>
<td></td>
</tr>
<tr>
<td>TOTAL ESTIMATED YEARLY OPEX</td>
<td></td>
</tr>
<tr>
<td><strong>£108,200</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 5 – CAPEX Table 6 – OPEX
In addition to the outlay of capital and revenue cost intelligent parking interventions also offer the possibility of increasing the income generated from parking. Estimates indicate that parking patronage in the areas equipped with bay sensors have a minor positive impact on patronage over areas without bay sensor monitoring deployed.

During development of this toolkit Future Cities Catapult undertook case study evaluations with Councils who had implemented similar solutions to give indicative figures on patronage increase. Taking account of corrective factors, i.e. the reduction in overall parking revenues in the wider area a general positive benefit on parking revenues was noticed. However it is unclear as to whether the improved service increases demand for equipped areas by taking patronage away from the non-equipped areas or not.

An indicative variation on revenue of 2% is shown in Table 7 and used to illustrate how it can be incorporated into further calculations in the breakeven analysis shown in Table 8 and Table 9.

Table 8 and Table 9 provide an example of a breakeven analysis on an intelligent parking solution. The net present value is the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyse the profitability of a projected investment or project. The formula used to generate this is illustrated in Table 7.

<table>
<thead>
<tr>
<th>Table 7: Revenue Variations</th>
<th>Baseline</th>
<th>After implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Revenue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Parking Revenue</td>
<td>15,000,000</td>
<td>15,000,000</td>
</tr>
<tr>
<td>Percentage uplift estimated</td>
<td>2.0%</td>
<td></td>
</tr>
<tr>
<td>Estimated uplift in revenue per annum</td>
<td>£300,000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 8: Breakeven Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakeven of intelligent parking</td>
</tr>
<tr>
<td>Total Estimated Yearly Fixed Cost of Sensors</td>
</tr>
<tr>
<td>Total Capital Cost of solution</td>
</tr>
<tr>
<td>Baseline revenue collection</td>
</tr>
<tr>
<td>Anticipated increase in revenue %</td>
</tr>
<tr>
<td>Annual Revenue Increase</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 9: Breakeven Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakeven Analysis Build Year</td>
</tr>
<tr>
<td>Purchase of Equipment</td>
</tr>
<tr>
<td>Baseline Income</td>
</tr>
<tr>
<td>Variation percentage</td>
</tr>
<tr>
<td>Income variations</td>
</tr>
<tr>
<td>Total Cost/ Income</td>
</tr>
<tr>
<td>Cumulative Position</td>
</tr>
<tr>
<td>Net Present Value</td>
</tr>
</tbody>
</table>
Another calculation worth considering is the Return on Investment (ROI) which is a measure of the efficiency of an investment, to compare a series of investments. It is a basic calculation of the return on investment relative to the cost of investment. The formula below illustrates how to calculate this and would return a ROI result of 0.24.

\[
\text{ROI} = \frac{\text{Gains from investment} - \text{Cost of Investment}}{\text{Cost of investment}}
\]

Task 3.3
Sensitivity Analysis

Sensitivity Analysis identifies costs and assumptions that cause significant uncertainty in the output of the cost benefit analysis. Once identified, through the process of Sensitivity Analysis, these inputs then become the focus of attention. In order to make the model more robust further analysis of these costs and assumptions takes place. In this way, Sensitivity Analysis provides an analytical framework for assessing and dealing with some of the risks to a successful intervention.

A formal process for carrying out a Sensitivity Analysis can be quite involved. However, for most practical purposes a simple three-step process can be adopted.

Step 1: The simplified approach involves first changing the inputs, CAPEX or OPEX items or assumptions regarding benefits, and noting to what extent this affects the output, the Break Even Point.

Step 2: Once the inputs which cause significant variation in the outputs have been identified, further analysis is carried out to define as accurately as possible the underpinning assumptions of that particular input.

Step 3: Any uncertainty which still exists can be dealt with by allowing estimates of costs and benefits to be spread over a range of values which reflect the uncertainty, the greater the uncertainty the wider the spread.

Sensitivity analysis is most beneficial when applied directly to the financial appraisal element of the business case of a given intervention.

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6 Discount Rate calculated from green book figure 3.5% for a 5 year project

IoTUK
Task 3.4
Leveraging IoT for Funding Access
As a footnote to Financial Analysis it is worth commenting that the nascent nature of the emerging global IoT market can offer a positive opportunity to leverage external funding. Funding instruments for pilot or wider scale roll-outs present themselves as money invested to prove the feasibility and benefits of the technology and the solutions.

The best, and perhaps most recent example, of direct investment in this area to prove the fundamentals of IoT was “The Internet of Things City Demonstrator” which is currently investing up to £10 million in a single collaborative R&D project to demonstrate the capability of IoT in a city region. The Demonstrator, funded by the UK Department for Culture, Media and Sport (DCMS) and administered through Innovate UK was successfully secured by the Manchester CityVerve Programme.

At the European level funding exists in Horizon 2020, European Regional (Euro Regional Development Funds) and at the National levels for the UK and England. Opportunities may also exist through the Local Enterprise Partnerships and various regional funding elements.

Generally speaking, these funding instruments give greater weight to solutions which offer transferability and proven success and this should be considered if looking to leverage funding in this manner.

This document is funded to contribute to the body of evidence supporting IoT investment and make deployment easier as part of the IoTUK Programme.