Connected Communities Research Lab | Lancaster University Management School

# Smart Parks

*Bringing new technologies to national parks and urban greenspaces*

Edward Truch and Juliana Sutanto

Connected Communities Research Lab

Commissioned by Lake District National Park

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## From the Authors

This study, commissioned by the Lake District National Park Authority, examines the opportunities for national parks and other protected spaces to benefit from recent and future developments in Internet of Things (IoT) technologies. We have developed the model of a Smart Park which draws on the latest information systems and sensing devices to provide a broad range of solutions that can enhance socio-economic and environmental aspects of these protected spaces. Such solutions are also applicable in the context of urban parks in Smart Cities.

Our ongoing research programme will continue to develop the Smart Park model and provide advice to support policy-making and the implementation of such systems. We aim to encourage innovation across a broad range of protected area aspects, including enhancing protected area tourist economies, visitor experiences, wellbeing of residents whilst contributing substantially to enhancing protection of natural landscapes, biodiversity, wildlife and the environment.

**Professor Edward Truch**

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The vision of the Connected Communities Research Lab (CCRL) is one in which people and objects are embedded and interacting within community settings in ways that enhance individuals' wellbeing and the environments in which they live and operate. The Smart Park model presented in this report is an exemplar of such connected communities. CCRL pursues interdisciplinary research for theoretical model building, empirical testing and implementation. Related action research involves collaboration with organizations in the operationalisation, validation, and further development of such models.

We welcome national and international collaboration in the co-creation of Smart Park solutions.

**Professor Juliana Sutanto**

## Forewords

This is a very new look at how designated natural areas and other green spaces, and the people that visit them, can benefit from the latest innovations in modern technology. It's about new ways of delivering conservation as well as visitor convenience and experience enhancement.

Commissioned by the same organisation responsible for the successful 2017 inscription of the UK's most recent UNESCO World Heritage Site, the English Lake District, this study will be of considerable interest to many people, including members of the UNESCO and IUCN networks, involved in land and people management.

**Chris Mahon**
Chief Executive, IUCN National Committee UK
Development Director, World Heritage UK

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This is a very inspiring and alerting report which shares an outlook of opportunities for updating parks to a Smart Park described as an ecosystem model. It provides a road map for some of the next steps to be taken.

For Smart Cities around the world Smart Parks will be an ecological necessity. It illustrates how Human Capital might be leveraged through Structural Capital combined with Nature.

Smart Parks might  become a space  for education and learning through smart devices, for different citizen groups, such as senior Silver potentials and youngsters in Generation Z. The Smart Parks could prototype salutogenic spaces and Mind Zones for Health, such as those evolving in Japan, into futurizing spaces as Wise Places through combinatoric innovation bringing together  IoT and Old Zen culture. Smart Parks are more than the lungs of a Smart City. They are the salutogenesis for health.

**Professor Leif Edvinsson**
The World's First Professor in Intellectual Capital, Lund University, Sweden
Awarded the KM Award 2017 together with UN

# Contents



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## 2 Executive Summary

Smart Park is a new concept that flows from the exponential growth in smart technologies and the Internet of Things (IoT). This study was commissioned by the Lake District National Park Authority with the aim of assessing the potential benefits of IoT for national parks and their many stakeholders.

The rapid growth in information and communications technologies (ICT) in the last twenty years is set to expand even faster as a result of the availability of faster and cheaper computing power in small devices coupled with substantial improvements in connectivity including fibre broadband, wireless 4G and 5G technologies, and open source wireless networks. The costs of equipment and communications have also tumbled spurring extraordinary growth in the user base across geographically dispersed markets. Forecasts from leading technology research firms are pointing to an expected five-fold expansion worldwide of devices connected to the Internet from 4.9bn in 2015 to 25bn in 2025.

The hitherto unknown levels of connectivity between people-to people, people-to-devices and devices-to-devices are disrupting many established businesses and creating new opportunities and some threats. Prime examples are those of Amazon who are leading in online retail enabled by extremely efficient supply chains and distribution networks. Booking.com has revolutionised the hospitality industry. AirBnB has created a new business model and marketplace for individual homeowners who can share their homes in ways that are trusted and profitable. The remarkable thing about all of these examples is the sheer speed of innovation that leaves behind many traditional businesses.

This study explores how these technological and market developments are likely to impact national parks in so many different ways and how they might be harnessed in future innovation that benefits the majority of stakeholders from nature conservationists, tourists, businesses and communities to park authorities and utility companies.

The vision of a future Smart Park is examined in detail. The potential benefits brought about by the introduction of smart technology and new ways of working are illustrated with real-life examples of early adoption in the UK and abroad.

Whilst many applications have already been successfully rolled out in Smart Cities around the world, some of the major obstacles to such development in national parks and rural areas more generally are rapidly being removed. Namely, the cost of IoT devices has dropped dramatically, in some cases to a fifth of their former prices. Devices that consume considerably less power coupled with low-cost high-capacity batteries mean that some devices can operate in remote areas for 5-10 years without recharging. New mobile network technologies such as narrow-band IoT (NB-IoT) can reach remote areas not currently served by mobile communications networks. Other areas which are served by 4G can make full use of geolocation services and video streaming. 5G which is still in development will provide much faster two-way communication and enable applications such as virtual reality and remotely controlled robotics, e.g. in forestry and agriculture.

A potential Smart Park development roadmap has been developed which describes different possible future paths that differ depending on the level of collaboration between stakeholders. A Smart Park maturity model demonstrates how a high degree of connectivity and exchange of information can lead to a high degree of park-wide business intelligence that equally benefits providers and users by reducing costs, creating new revenue streams, improving delivery of environmental objectives and enhancing the visitor experience. Such collaboration will require effective partnerships, e.g. the Lake District National Park Partnership[1].

Recommendations include mechanisms for encouraging business innovation through adoption of new IoT technologies whilst managing risks and ensuring sustainability of chosen solutions.

[1] Lake District National Park Partnership

# 3 Introduction

This Smart Park scoping study was commissioned by the Lake District National Park Authority with the aim of examining the latest developments in Internet of Things (IoT) technologies and how these might be deployed in a national park to enhance the delivery of the long term objectives of the Park Authority and its many partners and other stakeholders.

The study involved a comprehensive literature review, discussions with academic and industrial subject experts, professional institutions and systems suppliers. These were supplemented by a number of activities including a workshop with the Park Authority's strategic planning team, a physical survey of mobile network coverage in key tourist spots in the Lake District, and a Smart Park Hackathon[2] for eBusiness and Innovation MSc students at Lancaster University Management School.

## 3.1 Background

Unprecedented growth in new information and communications technology-enabled products and services across all sectors is creating enormous opportunities for innovation that can create new revenue streams, reduce costs and bring major improvements to many other aspects of national park.

Examples of early adoption include:

- **Visitor Experience** - real-time advice and directions for recreational activities, and visitor safety; alerts, warning and emergency response
- **Smart Transport** - real-time advice on parking availability, public transport alternatives and cycle routes
- **Fitness and Wellbeing** - planning exercise with real-time information and alerts so that people stay within their physical limits
- **Environment** - monitoring air and water quality, waste management, climate change measurement, and carbon footprint calculation

## 3.2 Report Outline

**Section 4 - Tomorrow's Smart Park** - Development of the Smart Park vision and creation of a 10-dimensional model which is used throughout this report

**Section 5 - Examples from around the world** - Innovations in national parks that are embracing IoT-enabled opportunities to introduce new products and services, new business models and new ways of managing and conserving parks

**Section 6 - Internet of Things** - Overview of key characteristics of the IoT, the specific technologies utilised, how these are applied in smart cities and can be translated into the context of national parks

**Section 7 - The Business Case** - Review of business models and their associated value propositions for all stakeholders

**Section 8 - Getting from Here to There** - Presentation of a 4-level Smart Park maturity model and its application in mapping future strategies and potential development roadmaps for innovation through IoT-enabled technologies. Key success factors and strategic alignment of key elements such as people, processes and technology are examined together with other implementation considerations

**Section 9 - Conclusions -** Summary of findings of the study including opportunities and challenges plus key success factors for developing a Smart Park and what steps a Park Authority might take.

[2] Video - Smart Park Hackathon

# 4 Tomorrow's Smart Park

## 4.1 Smart Park Definition

A Smart Park is defined for the purpose of this report as follows:

**A national or urban park whose operations are enhanced by effective use of the Internet of Things (IoT) for the benefit of its stakeholders.**

Effective utilisation of an Internet of Things infrastructure is a key element of the Smart Park vision (illustrated in Figure 1 below)

## 4.2 Related definitions

**International Union for Conservation of Nature (IUCN)'s definition[3] of National Park (Category II)**
"Large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities".

**England and Wales' definition of National Park**
"The Environment Act 1995 set out the following three purposes:
"(i) conserve and enhance the natural beauty, wildlife and cultural heritage; (ii) promote opportunities for the understanding and enjoyment of the special qualities of national parks by the public; and (iii) seek to foster the economic and social well-being of local communities within the national parks"

**Environmental Industries Commission (EIC)'s definition of Smart City**

"Smart City applications are those which are based upon using the power of networked devices (both centrally controlled and citizen controlled) and analysis of 'big data' to improve the functioning and capability of cities"

Figure 1. Tomorrow's Smart Park

[3] IUCN - National Park definitions

## 4.3 Smart Park model

The model presented in Figure 2 below describes the ten key dimensions of a Smart Park and is used throughout the rest of this report.

**Smart Tourism -** Hospitality, attractions, associated visitor services, retail trade, local businesses, and the rural economy as a whole

**Smart Mobility -** Multimodal transport integrating trains, buses, cars, boats, cycling and travel by foot including, fell walking and mountain climbing. Smart parking

**Smart Community -** Vibrant community of both visitors and residents. Community resilience, emergency preparedness, education for all ages particularly in subjects related to the ecology of the park.

**Smart Wellbeing -** Physical and psychological wellbeing. Security so that residents and visitors feel safe at all times. Facilities and programmes that encourage healthy outdoor recreational activities.

**Smart Landscape and Heritage -** Enjoyment of the spectacular scenery of the park. Facilitate access to the park in a sustainable and responsible way. Cultural heritage. Land management.

**Smart Nature -** Enhancement of the natural capital of the park and support of conservation of plants, trees and animals. Conservation of rare species and maintaining biodiversity, wildlife and forests.

**Smart Environment -** Ensuring a healthy and sustainable environment. Continuously reducing the carbon footprint of human activity in the park. Effective waste management, limiting air, soil and water pollution. Mitigating climate change and effective carbon reduction management. Flood resilience measures and effective early warning systems operating at regional and local community levels.

**Smart Agriculture -** Effective farming that increases productivity and animal welfare whilst reducing use of fertilizers and pesticides. Effective irrigation systems that maximise the use of resources. Farmland management.

**Smart Governance -** Enhanced management of the park through increased provision of information systems supported by real-time data from many more sources around the park augmented by external data provision. Enhanced information management using latest advances in data science and business intelligence systems. Knowledge management systems.

**Smart Infrastructure -** IoT technologies deployed throughout the park in systematic ways, fully integrated within a park-wide framework of devices and systems.

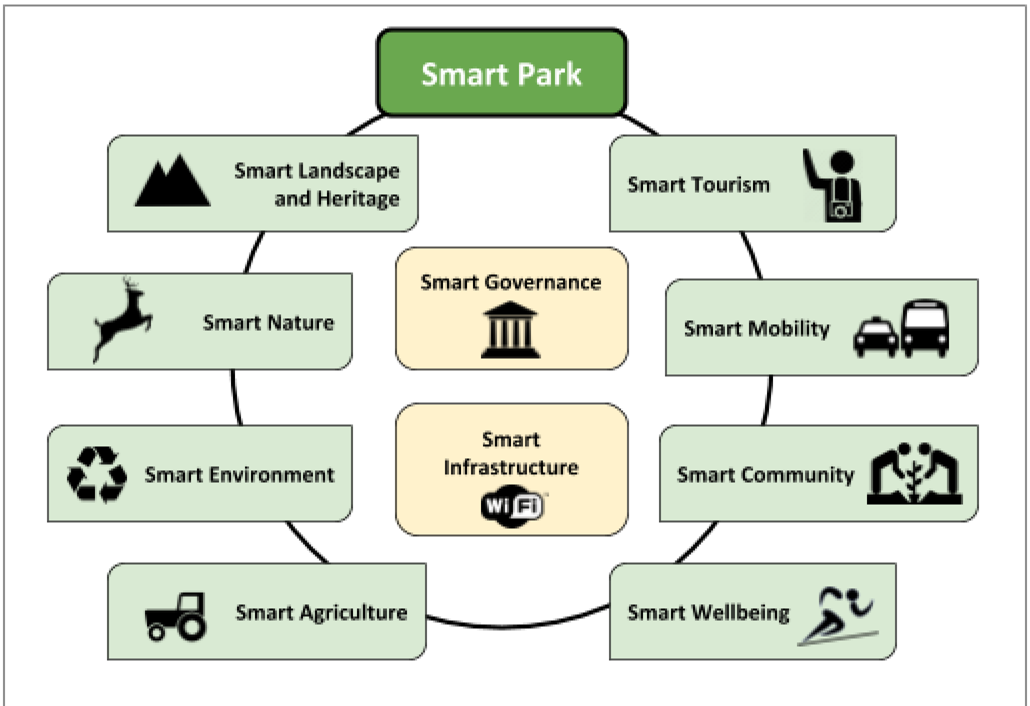



Figure 2. Smart Park model

## 4.4 Partnerships

To test the relevance of the many actual and potential applications of IoT to a national park, the English Lake District was selected as an example. The table in Figure 3 below demonstrates how the Smart Park dimensions map onto all the Lake District vision elements which are described in the Park Authority's strategic plans. It is clear that each of the four elements of the Lake District vision stands to gain from IoT technologies.

Some national park authorities in the UK and abroad have created partnership organisation to bring together various park stakeholders in order to facilitate joined-up thinking and ways of working to create synergistic relationships that benefit the parks as a whole and individual organisations at the same time.

A prime example of such a partnership is that of the Lake District National Park Partnership which was formed in 2006 and continues to operate successfully through collaboration and joint economies of scale. The Partnership vision[4] is built on the following four elements:

**Prosperous Economy**
Growing rural economy, profitable farming and forestry businesses

**World Class Visitor Experience**
Strengthened tourism sectors by extending the quality and international appeal of this visitor destination

**Vibrant Communities**
Opportunities for more affordable and local needs housing; integrated and sustainable transport network that enables people to travel by attractive, affordable and environmentally friendly means across the park

**Spectacular Landscape, Wildlife & Cultural Heritage**
Valley planning working with partners and communities; healthy, diverse and high quality biodiversity on land and in water; climate change and carbon reduction management

The table below indicates which elements of the Lake District vision stand to be enhanced across the Smart Park dimensions.

| Smart Park Dimension | Lake District NP Partnership Vision | | | |
|---|---|---|---|---|
| | Prosperous Economy | Visitor Experience | Vibrant Communities | Landscape, Wildlife, Heritage |
| Smart Tourism | ✔ | ✔ | | |
| Smart Mobility | | ✔ | ✔ | |
| Smart Community | ✔ | | ✔ | |
| Smart Wellbeing | | ✔ | ✔ | |
| Smart Landscape and Heritage | | ✔ | | ✔ |
| Smart Nature | | ✔ | | ✔ |
| Smart Environment | | | ✔ | ✔ |
| Smart Agriculture | ✔ | | | ✔ |
| Smart Governance | ✔ | ✔ | ✔ | ✔ |
| Smart Infrastructure | ✔ | ✔ | ✔ | ✔ |

Figure 3. Smart Park dimensions and application grid

[4] Lake District Park Partnership management plans

# 5 Examples from around the World

## 5.1 Introduction

Early examples of IoT-deployment in national parks around the world demonstrate not just the feasibility of successfully implementing such systems but also point to the substantial benefits that can be derived in many different ways. IoT-enabled systems in national parks are generally at an early stage of development and accordingly the examples presented are those of early adopters and as such represent 'pockets of the future' that others are likely to follow.

Examples have been identified for each of the ten dimensions of the Smart Park model (see figure 2 in section 4.3). They generally cover systems that support the conservation and management of national parks and in some cases large urban parks. They range from single issue solutions such as smart bins to fully developed infrastructures with comprehensive coverage of most Smart Park dimensions.

Whilst not directly relevant to national parks, theme park management systems such as those of Disneyland, Legoland and Singapore Garden City serve as good examples of fully integrated systems with sophisticated analytics and management information systems. These are clearly very well resourced and leverage the benefits of single land ownership and economies of scale. Nonetheless, many aspects of their IoT systems can be readily translated into the context of national parks.

The technologies utilised in these examples span a broad range from simple sensors such as temperature and pressure to leading edge systems using drones (UAV), virtual reality (VR) and artificial intelligence (AI) for analytics, control and management systems.

Various data communication channels are covered from fast fibre broadband to wireless technologies, from 4G to low power long range systems such as Narrow Band IoT (NB-IoT) and independent communications networks such as LoRaWAN (described in Section 6).

Each example contains a short description and links to source websites for more information when viewed online.

Please note that the examples presented in this section are only loosely categorised within one of the ten Smart Park dimensions as many are cross-cutting in nature and fit well within several categories.

## 5.2 Smart Tourism

### 5.2.1 KONUS Guest Card in Black Forest, Germany


source: KONUS

Through its KONUS[5] scheme the Black Forest National Park in Germany provides free bus and rail transport in order to encourage more tourists and reduce traffic congestion and pollution at the same time.

The tourist promotion states: "Arrive at your holiday destination, park your car, and start your hiking trip. Embark on a journey of discovery of the region or enjoy culture and shopping in one of our homely cities and all without worrying about finding a parking spot for your car. Nobody needs to worry about fare zones and finding change. It's best to ask for information on the KONUS Guest Card before booking. Then the entire Black Forest will be yours!"

Most villages and municipalities within the Black Forest participate in the KONUS scheme.

[5] KONUS - Black Forest Tourism

### 5.2.2 Visitor Magic Band

source: smaXtec

Disney World's MagicBand[6] is available to all visitors and connects them to the park's extensive network of people and things. This makes for a much smoother visitor experience with less delays, reduced ticketing, advance reservations at attractions and eateries, and much more. For example, restaurant staff know what guests have ordered in advance and where they have decided to sit.

Thousands of sensors communicate with each other through numerous systems that are linked together to create MyMagicPlus, which is  effectively it's own Internet of Things streaming real-time data about where guests are, what they're doing, and what they want. It's designed to better understand and anticipate visitors' needs. Signing up in advance eliminates the hassles of registration on arrival together with all the associated paperwork.

## 5.3 Smart Mobility

### 5.3.1 Greenwheels car rental in Netherlands

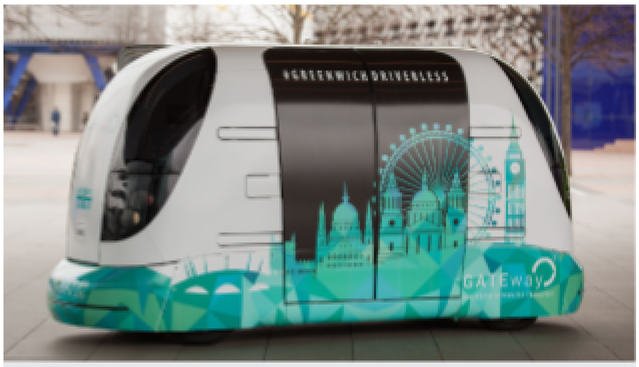

source: Greewheels

Greenwheels[7] the largest car sharing operation in the Netherlands provides an integrated travel service in partnership with NS Rail. Cars are available from more than 1,700 locations throughout the Netherlands and almost 100 NS rail stations.

The company says: "Simply pick one up and return it whenever you want. That saves you a lot of hassle. Never have to worry about insurance, motor vehicle taxes, parking or maintenance. And it's also much more environmentally friendly." People want to be able to move around without having to worry. It's "Fast, safe, simple and at any time".

NS has developed into a comprehensive service provider, enabling its customers to blend social, business and recreational goals seamlessly.

### 5.3.2 Gateway driverless shuttle bus tests in London




source: Gateway / TRL

The GATEway[8] (Greenwich Automated Transport Environment) project is an £8 million research project to develop and investigate the use, perception and acceptance of fully automated vehicles in the UK. Using a combination of sensors, cameras, lasers and software from Oxbotica, the vehicles safely navigate their way around Greenwich.

The Future of Transport project led by TRL[9], aims to understand and overcome the technical, legal and societal challenges of implementing automated vehicles in an urban environment.

Taking place in TRL's UK Smart Mobility Lab in the Royal Borough of Greenwich, the project will trial and validate a series of different use cases for

[6] Disney magicband (Wired magazine)

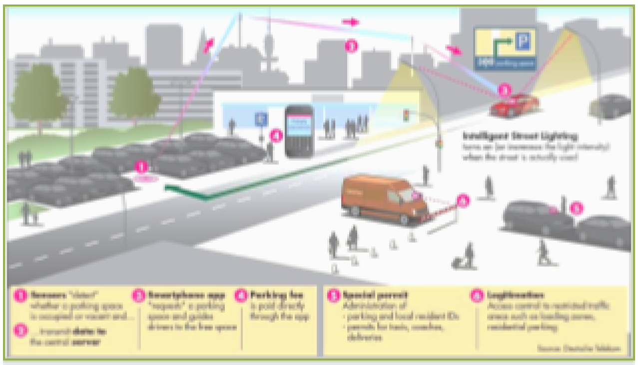
[7] Green Wheels

[8] Gateway project

[9] TRL

automated vehicles, including driverless shuttles and automated urban deliveries.

### 5.3.3 Smart Parking in Pisa, Italy



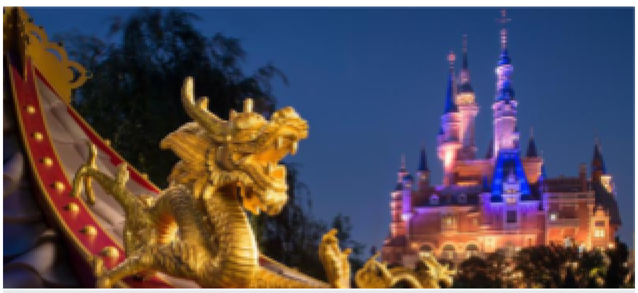
source: Deutsche Telekom

The Italian city of Pisa has formed a partnership with Deutsche Telekom to launch a smart city pilot project to optimise inner city parking (see TelecomTV[10]). The project analyses historical traffic data via a big data service. Pisa attracts around 90,000 vehicles per day.

Sensors on the floor of each parking spot detect whether they are free or occupied, and data units then collect this information and send it over the mobile network to the city's server infrastructure. It is then sent to street-side indication panels, which guide drivers to a free space. The solution is also integrated in Pisa's existing Tap & Park app, which drivers can choose to download to take them directly to a free parking space, as well as using it to pay for parking.

Pisa has a Sustainable Energy Action Plan that includes the goal of reducing $CO_2$ emission by more than 20 percent by 2020.

### 5.3.4 Smart Parking in Shanghai Disneyland



source: Shanghai Disneyland

Huawei, China Unicom and Shundu (Disney's agent) have reached an agreement to introduce 4.5G to the Disney resort. Plans include monitoring the flow of people around the resort and smart parking, which Huawei intends to bring to the market next year.

Shanghai Disneyland[11] will boast the largest Disney castle in the world. Disney says the resort will showcase the best of its storytelling while celebrating China's heritage. Major construction is complete and the resort has hired almost 2000 cast members and staff for its design and development arm.

In 2016 Huawei, in partnership with China Unicom, trialled parking sensors placed in the road to detect a car's movement in and out of a designated space. Not only can approaching drivers be notified of a free space, drivers moving out of spaces in future could be billed through an app.

## 5.4 Smart Community

### 5.4.1 Citizen Preparedness app in Southern Nevada


source: QuickSeries

The Citizen Preparedness[12] app helps residents and visitors in Southern Nevada to be better prepare for emergencies. Clark County and the cities of Henderson, Las Vegas and North Las Vegas have partnered to create a smartphone app specifically designed to help the Southern Nevada community prepare for and respond to emergencies.

Available for free download, the smartphone app puts the tools and information that individuals and

[10] TelecomTV - Pisa article

[11] Shanghai Disney Resort

[12] Clark County, Nevada - Citizen Preparedness

families need to prepare for an emergency in their pockets. The app allows users to:

- Create a personalized emergency preparedness plan
- Access news, real-time weather alerts, evacuation routes, and emergency shelter information
- Receive critical emergency alerts directly to their smartphones via push notifications
- Find out what they need to do before, during and after an emergency
- Share their safety status with loved ones with the push of a button
- Connect to social media sites

Users can create an emergency preparedness plan by answering five basic questions. Based on their answers, the app will generate an emergency supply kit list and checklists tailored to their individual or family needs.

The app can be downloaded from this link: [www.equickseries.com/eoc32003/core/v1/getApp](www.equickseries.com/eoc32003/core/v1/getApp)

The app is produced by Quick Series who provide over 500 titles. They maintain partnerships with key organizations such as the Cooper Institute and the International Critical Incident Stress Foundation.

### 5.4.2 British Red Cross' Community Resilience app

source: British Red Cross

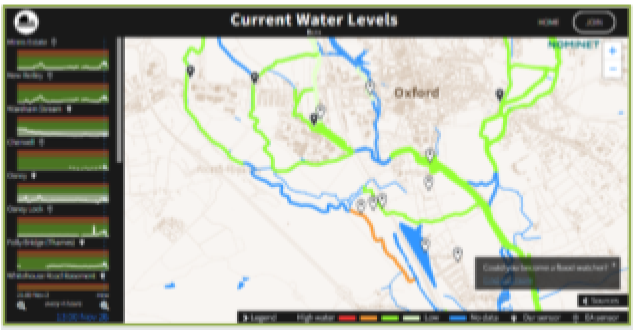
The British Red Cross[13] Emergency App provides real-time, personalised emergency alerts to "help you and your loved ones stay safe". It helps people prepare for emergencies and know exactly what to do if the worst happens. The free smartphone app offers the following:

**Alerts** - Get tailored push notifications delivered straight to your pocket. Add the places and people you care about to get severe weather warnings from the Met Office, flood warnings from the Environment Agency (England only), UK Threat Level updates, and alerts from the British Red Cross.

**Advice** - Stay safe by checking what to do before, during and after emergencies such as fire, flooding and power outages.

**Toolkit** - Check your current location, use a flashlight and alarm, and tell people that you're safe.

### 5.4.3 Oxford Flood Sensor Network



source: Oxford Flood Network

The Oxford Flood Network[14] is a citizen-based initiative for water-level monitoring sensors - a "guerilla network" in the spirit of the crowdsourced Japan Radiation Map created by the public around Fukushima in response to a lack of official information. Oxford is prone to flooding. Although the Environment Agency provides blanket warnings, they have limited resources. To help understand flooding at a street level more data is needed on the streams, groundwater and the complex basin of the Thames & Cherwell providing higher resolution data.

The project aims to show how to monitor water levels in local communities using the Internet of Things and wireless sensors. In the floodplain of Oxford members of the local community are installing their own water-level monitoring sensors and sharing local knowledge about rivers, streams and groundwater to build a better, hyper-local picture of the situation on the ground.

It links to the UK-wide Flood Network - [https://flood.network](https://flood.network)

13 Red Cross Emergency app

14 Oxford Smart City Flood Network

### 5.4.4 Calderdale Flood Sensor Network

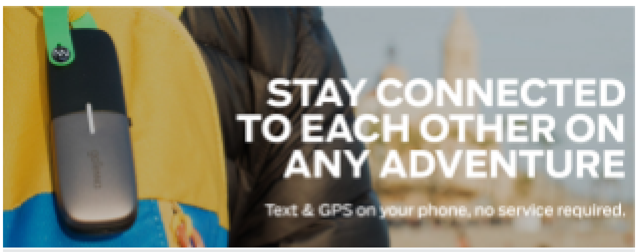

source: British Red Cross

The Calderdale Flood Sensor Network[15], an extension of the Oxford Flood Network (see previous section), has been set up by volunteers in Calderdale, Yorkshire, a region in the North of England which has been affected by severe flooding several times. The last flooding happened at the end of 2015. The system utilises a low-power wide-area IoT network technology, LoRaWAN, which is designed for this type of low-power, long-range, low-battery, outdoor and low-data Industrial Internet of Things application. It was built by AB Open (http://abopen.com)

The plan is to grow from a still relatively small operation to a broader platform with the help of the local community whereby people can have a sensor installed to monitor river and groundwater levels. See video at: https://youtu.be/TxMpNsS-oro

The initiative is a member of The Things Network - https://www.thethingsnetwork.org/

### 5.4.5 Gotenna mesh




source: gotenna mesh communicator

The goTenna Mesh[16] wearable device enables text and GPS on a phone that is totally off-grid. Its mesh networking technology also means that if someone is out of point-to-point range, their messages will relay automatically and privately through other users in the area.

The device pairs with regular smartphones via a simple messaging app. By typing a message one can send GPS location, and access free offline maps for the whole world via the goTenna app.

goTenna devices eliminate channel-switching and interference, and offer delivery receipts, private 1-to-1 or group chats, and public broadcasts - all creating the future of off-grid communications.

The goTenna Pro version offers live interactive mapping, text messaging, personnel tracking, point marking, perimeter/route marking and can trigger automatic emergency beacons.

Video - https://vimeo.com/184624592

## 5.5 Smart Wellbeing

### 5.5.1 Microsoft's Project Premonition

source: Microsoft

The project turns mosquitoes into allies. Many disease outbreaks start from viruses found in animals. Microsoft's Project Premonition[17] aims to monitor these viruses using mosquitoes as natural field biologists that collect blood samples from animals. When mosquitoes bite animals, they obtain a small amount of blood containing genetic information about the animals that were bitten and viruses present. This information can be used to detect pathogens before they cause outbreaks.

The aim is to utilise these insects' work to identify where diseases come from and how they spread and ultimately prevent outbreaks of new viruses by using smart traps, drones and gene sequencing to capture mosquitoes and study their DNA.

[15] Calderdale Flood Sensor Network (i-scoop.eu)
[16] https://www.gotenna.com/
[17] Microsoft's Project Premonition

## 5.6 Smart Landscape and Heritage

### 5.6.1 Google's Art & Culture Virtual Tours of US National Parks

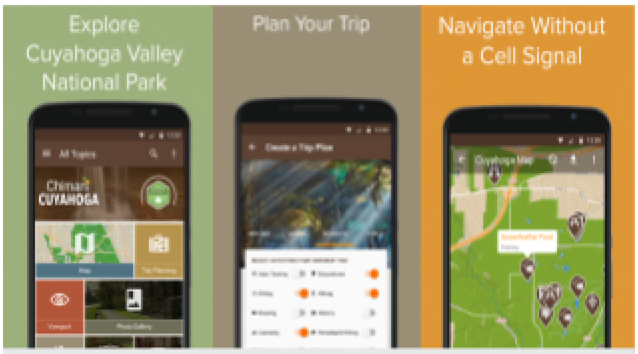

source: Art & Culture with Google

To mark its centennial, the US National Park Service has teamed up with Google to launch a project[18] that makes the parks more accessible by bringing online as much of their experience as possible. "The National Parks are full of wonders, but most people don't get the chance to visit in person," writes Nick Carbonaro, the project's creative lead. "We wanted to see if we could use Google's technology to help share parks with everyone."

The project has launched with virtual tours of the main attractions in five parks: Alaska's Kenai Fords, Hawaii Volcanoes, New Mexico's Carlsbad Caverns, Utah's Bryce Canyon, and Florida's Dry Tortugas.

Each virtual reality experience is narrated by a local ranger, and includes a video walk-through, as well as 360-degree views of popular scenes, complete with audio recorded on-site. The experience is available through desktop web browser, smartphone or tablet via a variety of apps.

### 5.6.2 Virtual Ranger apps




source: Chimani

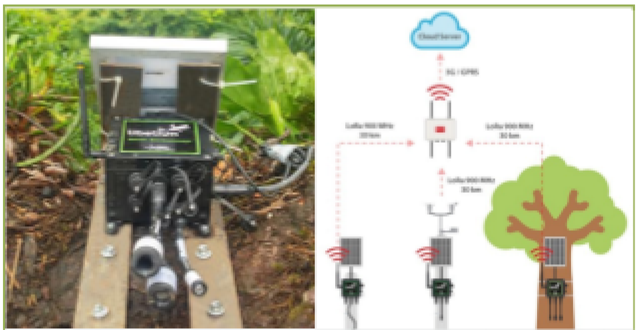
Smartphone apps produced by Chimani[19] working in partnership with the US National Park Service cover all 59 US national parks. They effectively provide virtual rangers who accompany visitors on their trails through the parks.

The intuitive apps draw on the power of GPS-enabled interactive mapping technology to guide one through outdoor adventures. The apps include descriptions of points of interest, trails, amenities, and more. The apps work with or without WiFi or data signal. Features include an easy-to-use interface based on universal national park symbols, push notifications for park-related news, alerts and events. One can tag favourite park sights, collect points and earn badges for visiting parks and points of interest.

Chimani have recently launched an app for the English Lake District[20]

## 5.7 Smart Nature

### 5.7.1 Natural Habitat monitoring in Manu National Park, Peru



source: Libelium

The Manu National Park[21] in Peru, a UNESCO world heritage centre, is one of the most important natural reserves and houses the largest biodiversity in the world. Despite the fact that this variety of plants and animals is protected, they are threatened by climate change.

In order to preserve these species several researchers in Peru have spearheaded a project with the aim of monitoring the natural behavior of the jungle and its habitat in real time with IoT connectivity.

18 Arts & Culture with Google - NPS

19 Chimani - US National Parks

20 Chimani - English Lake District

21 Digital AV Magazine - Manu National Park

The Waspmote Plug & Sense Smart Environment system[22] provides measurements of temperature, humidity, CO2, NO2, O2, CO, CH4, O3 and atmospheric pressure.

### 5.7.2 National Parks in Africa

source: Lian Pin Koh, Orangutan nests

IUCN commissioned report: The Internet of Things for Pendjari National Park: A Phased Innovative Technology Investment Strategy to Improve Management Effectiveness[23]

This report provides a comprehensive review of the application of IoT in the Pendjari National Park and other protected areas. It demonstrates the potential for smart technologies to transform the management effectiveness of protected areas in Africa and elsewhere. The IoT applications address challenges in the following areas:

- Automated collection of ecological data
- Automated surveillance of the park
- Security of staff and tourists
- Security of local communities
- Improving the visitor experience
- Stakeholder collaboration systems

The image above[24] is a collage of Orangutan nests in Sumatra identified by UAV (drone) to monitor their population dynamics and wellbeing.

[22] Libelium plug and sense modules

[23] IoT for Pendjari National Park (IUCN mission report)

[24] www.orangutan.com

## 5.8 Smart Environment

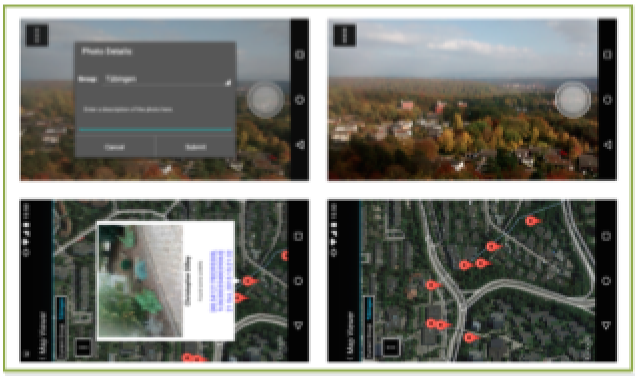
### 5.8.1 Environmental Monitoring in Hyde Park, London


source: ICRI Cities

ICRI[25] Cities (Intel Collaborative Research Institute) are partnering with the Future Cities Catapult and The Royal Parks to implement an Environmental Monitoring project focusing on London's Hyde Park. It will test an innovative network of wireless sensors, including soil, air, water and more. See video[26]

Using the data gathered, they aim to deliver new solutions that could include anything from apps that tell asthmatics how to navigate the city with minimum exposure to air pollution, through to new business models that allow the green spaces to prosper in the face of uncertain funding.

### 5.8.2 Smart Earth Citizen Science



source: Smart Earth Network

The Smart Earth Network[27] (SEN) provides a citizen science app with which people can set up a community of watchers to jointly capture sightings of whatever they are interested in, and view those sightings on a map. It is a simple but very flexible and powerful citizen science tool called WeLog. The

[25] http://cities.io/index.html

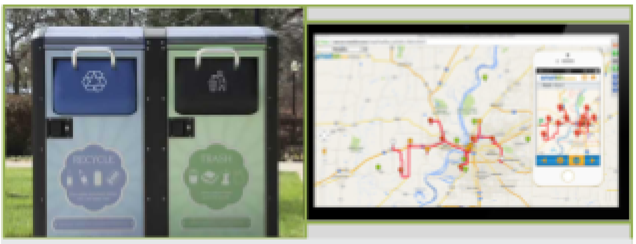
[26] https://vimeo.com/176462997

[27] http://www.smartearthnetwork.com/pages-90

app can be downloaded to Android smartphones and tablets. Possible uses include:

- Holiday photo-albums
- Logging animal sightings, invasive species, environmental incidents.
- Logging evidence of crime.
- Logging issues in your community or neighborhood, e.g. potholes, graffiti or other vandalism.
- Teachers working with pupils on field trips.

### 5.8.3 Smart Bins



source: Big Belly and SmartBin

Companies such as Bigbelly[28] and Smartbins[29] are changing the waste management paradigm by creating intelligent infrastructures that deliver ongoing operations and free up staffing and resources to support new and expanded recycling programmes.

By knowing the fill-levels of all the waste containers in a connected system, one can plan smarter routes that cut out unnecessary journeys and substantially reduce fuel consumption.

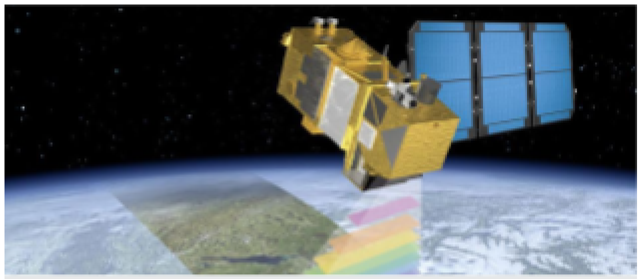
Other benefits include reduced numbers of waste collection visits due to automated waste compression built into smart bins and provide real-time data alerts when bins will soon need to be emptied.

Strategically placed smart bins can be used for siting other IoT sensors and devices that together form part of a park-wide intelligence system.

[28] http://bigbelly.com/
[29] https://www.smartbin.com/

## 5.9 Smart Agriculture

### 5.9.1 Earth Observation satellite programme



source: Airbus

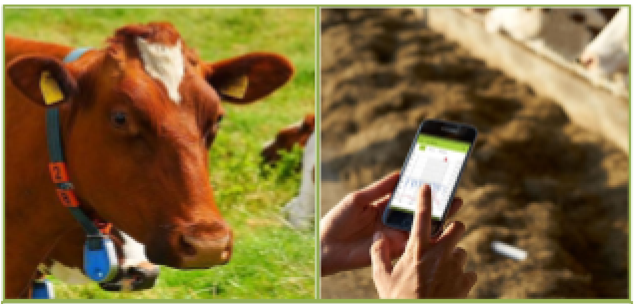
The EU Copernicus[30] satellite project run by Airbus comprises a family of Sentinel series satellites that are designed to observe the earth in all weather conditions. They have multi-wavelength detectors to study land and ocean changes. High and low orbiting satellites measure atmospheric gases and air quality. The global monitoring programme addresses six specific topics: oceans, atmosphere, climate change, land, security and emergency management.

Data feeds will support services in the following areas:

- Agriculture: Gathering crop statistics and yield assessments
- Urban: Planning city-wide infrastructure improvements
- Forests: Checking de- or re-forested areas for treaty purposes
- Biodiversity: Understanding the habitats where wildlife exist
- Health: Tracking conditions associated with disease spread [31]
- Water: Evaluating water body extents for flood assessments
- Disaster: Making damage maps following major earthquakes
- Cryosphere: Mapping snowfields and glacier melting

[30] Copernicus satellite programme (Airbus)
[31] http://www.bbc.co.uk/news/science-environment-31483629

### 5.9.2 Smart Cattle



source: smaXtec

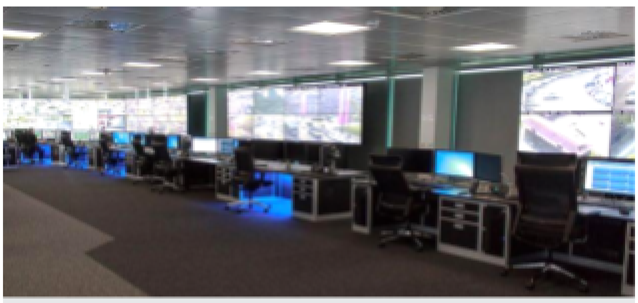
Cows across the world are texting farmers their health updates. Utilising the Internet of Things (IoT), companies such as SmaXtec[32] are placing connected sensors inside cows' stomachs to transmit health data over Wi-Fi. The monitor tracks the cow's health and sends a text message to the farmer when she is pregnant. This technology is already in use in over twenty countries.

A sensor is placed into one of the cow's four stomachs through the throat and transmits real-time data about the temperature of the cow, the pH of her stomach, movement, and activity. A base station in the barn picks up the signals and uploads all of the data to the cloud.

If the cow falls ill, the system e-mails the vet, generally before the cow is obviously sick. When a cow is pregnant a text message will be sent to the farmer and his team, so that they can take action accordingly.

## 5.10 Smart Governance

### 5.10.1 Glasgow traffic monitoring centre



source: Future City Glasgow

Glasgow Operations Centre[33] is a state-of-the-art integrated traffic and public safety management system created with the aid of Innovate UK funding.

The new centre brings together public space CCTV, security for the city council's museums and art galleries, Traffic management and police intelligence. The facility has the capability to provide a coordinated, real-time, intelligence-led response to incidents large and small across the city, and forms an important element of its smart city management.

Video analytics is a pivotal tool used as an additional intelligence source. This emerging technology provides Operations Centre operators with alerts as situations and events unfold, resulting in improved, better informed decision-making, and earlier intervention and reaction to events. Promoting a safer and sustainable environment, intelligence from the Operations Centre will be managed and mapped to monitor and measure a range of indicators showing its impact and value on behalf of Glasgow's residents, businesses, visitors and other stakeholders.

### 5.10.2 Smart Park Management Systems

Smart Park IOT ecosystem

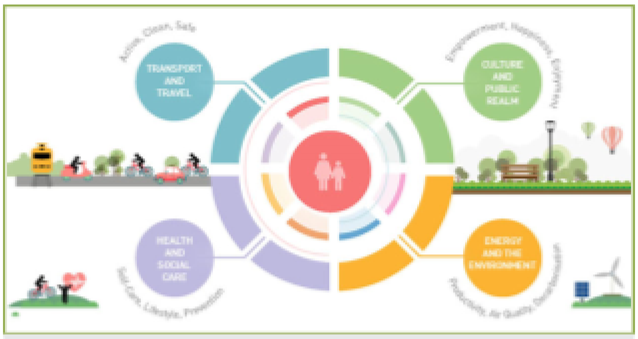
IoT-based systems by companies such as Smartpark Control[34] in Australia and Synjones[35] in China provide management platforms that help monitor, control and manage most key aspects of a national park. Cloud based solutions provide real-time management information through comprehensive dashboards that can be viewed and controlled through desktop and mobile devices.

In addition to interactive management information systems the platforms can also enable various tourist and community services that contribute to an enhanced visitor experience. Such systems underpin the infrastructure necessary to enable the key dimensions of the Smart Park model (section 4.2).

32 smaXtec monitoring systems
33 Futurecity, Glasgow
34 Smart Park Controls, Australia
35 Synjones - China

## 5.11 Smart Infrastructure

### 5.11.1 CityVerve, Manchester's Smart City Demonstrator




source: CityVerve, Manchester

The CityVerve[36] initiative brings together the brightest minds and pioneering uses of Internet of Things (IoT) technologies to redefine 'smart' in the context of a living, working city. It brings together all of the different themes and elements that make a 'smart city', rather than viewing them as disparate clusters of technology. In order to achieve this a genuine world-first 'platform of platforms' is being built to connect data, systems and people at city scale - imagine CityVerve as a brain's neural pathway: the more connections made, the smarter the city will become.

A structured open innovation programme at the heart of the project will enable literally anyone, from entrepreneurs, start-ups and developers to large corporates and service providers, to develop on the CityVerve platform. This will give rise to even greater potential for innovation and the delivery of tangible value to those who live, work and play in Manchester.

### 5.11.2 Dubai Parks and Resorts

source: Dubai Parks and Resorts

Dubai Parks[37] and Resorts and Etisalat have announced they will collaborate to make the region's largest integrated theme park destination the Middle East's first 'smart' resort. This will involve a park-wide IoT system and security infrastructure. It will also implement smart ticketing, digital payments, smart parking, connected transportation, connected food and beverage, as well as retail and digital entertainment.

Raed Kajoor Al Nuaimi, CEO, Dubai Parks and Resorts, states: "Today, we live in a digital world and our guests expect a fully integrated digital experience. Our partnership with Etisalat delivers on this expectation, and will enable access to Dubai Parks and Resorts in many forms. From booking tickets, to finding parking spaces, to choosing rides with lower wait times or deciding on the right cuisine to eat, this collaboration will facilitate an unforgettable trip for visitors with few simple clicks on their smart devices."

[36] City Verve

[37] Dubai Parks & Resorts (Middle-East Hotelier)

# 6 Internet of Things

## 6.1 Smart Technologies

The ‘Internet of Things’ (IoT) has been variously defined and in essence comprises an information exchange ecosystem of people-to-things, and things-to-things networks. In this context the things include a vast array of sensing devices and actuators that cause events to occur such as the presence of a person entering a room detected by a motion sensor which consequently activates a light switch. From this simple example IoT networks extend to massive networks on the scale of whole cities and beyond. Most of such devices connect to and communicate through the global networks of the Internet. Some IoT systems can be closed and operate independently.

A more formal definition provided by the International Telecommunications Union (ITU)[38] is as follows:

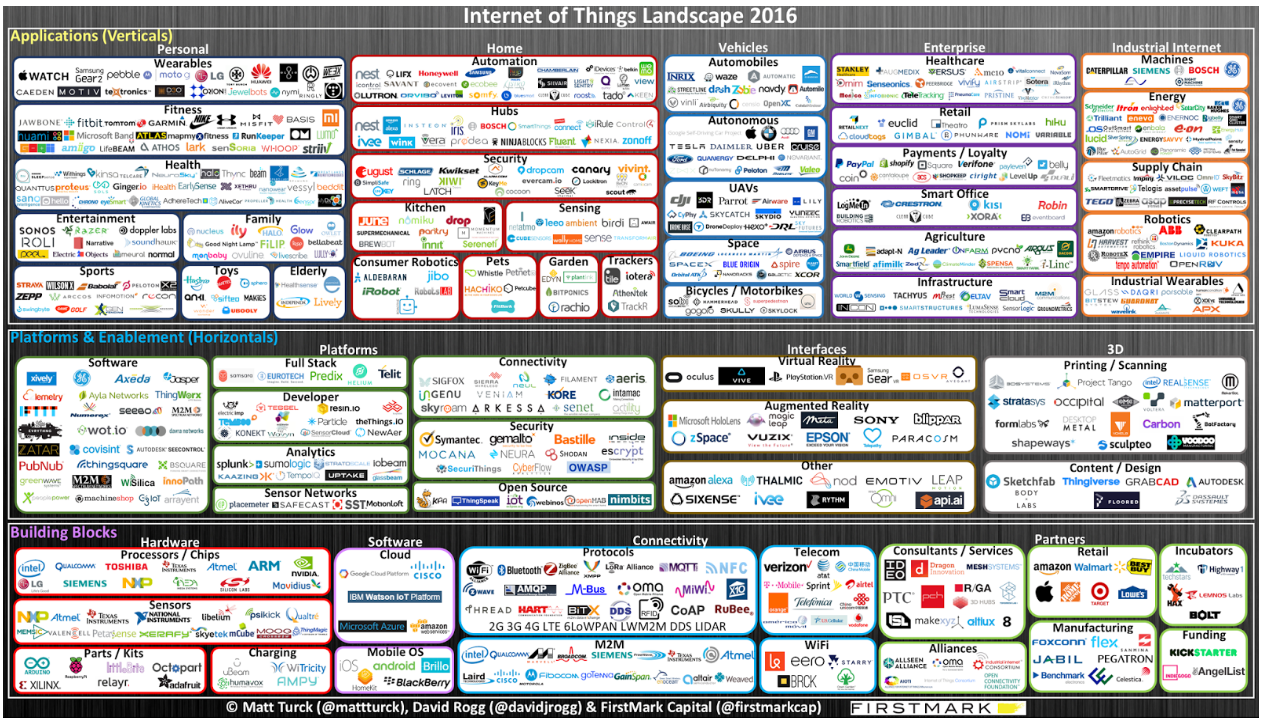
*The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.*

Growth forecasts of the IoT market vary, but there seems to be broad agreement amongst leading strategy consultancies such as Gartner, IDC and McKinsey[39] that the global IoT market will grow from 4.9bn in 2015 to 25bn in 2025.

The complexity of the IoT marketplace with its many overlapping categories of equipment suppliers and service providers is illustrated by the chart below (section 6.2). Providers are continuously innovating and extending the range of their offerings to the point that they often overlap which makes it difficult to distinguish between them. For example, Netatmo [40] who first made their entry into the market with weather stations and rain gauges have now extended their offering to security systems providing a comprehensive online monitoring and notification system as well as smart home heating management.

## 6.2 General IoT Landscape

The chart below illustrates the large range of IoT solutions and providers[41]. The high level of complexity of the supply market and rapidly growing number of products and solutions poses considerable challenges for prospective buyers.




[38] ITU definition of Internet of Things

[39] McKinsey IoT semiconductor market analysis

[40] Netatmo - weather app

[41] IoT Landscape table by Matt Turck et al.

## 6.3 Smart Park IoT Ecosystem

The Smart Park IoT Ecosystem framework in Figure 4 below describes the key elements that make up a Smart Park.

Each of these elements is described in turn in the following sections 6.4 to 6.11. They effectively form the hierarchically arranged layers (L1 to L8) of a composite structure that starts with devices (L1) which produce and receive data (L2). The data is transmitted via connectivity channels (L3) to and from the IoT platforms (L4) which comprise complex arrays of data centres which store and process the data.

The solutions layer (L5) addresses specific requirements through software applications for smartphone and other interactive display devices that enable users to carry out everyday tasks such as route planning, booking taxis and hotels to managing more complex business processes remotely.

Data analytics techniques (L6) generate additional results using several interactive display modes so that various cognitive methods (L7) are utilised by people and computers supported by artificial intelligence in developing actionable insights that support decision-making in its many forms.

The top tier of the IoT stack (L8) represents the organisational intelligence that enables smart management of individual park organisations and all stakeholders working collaboratively to form a kind of park-wide neural network that enables sense-making from the vast array of data generated continuously by the many elements of the Smart Park. Taken together, these should lead to a deeper understanding of the functioning of the Park as a whole and more actionable insights.

| IOT Layers | | Elements |
|---|---|---|
| 8 | **Intelligence** | Park-wide organisational intelligence<br>Business model innovation<br>New revenue streams, new efficiencies |
| 7 | **Cognitive** | Visualisation and management dashboards<br>Augmented (AR) and Virtual Reality (VR)<br>Reporting actionable insights |
| 6 | **Analytics** | Data analytics<br>Aggregation from multiple data sources<br>Artificial intelligence (AI) |
| 5 | **Solutions** | Process automation<br>Management Information Systems<br>Smartphone and desktop applications |
| 4 | **IOT Platforms** | Park-owned or co-managed IOT platforms<br>3rd party IOT platforms<br>Data storage and security |
| 3 | **Connectivity** | Core Platforms & Radio interfaces<br>Mobile networks such as NB-IOT, 3G, 4G, 5G<br>Open source mesh networks; LoRaWAN |
| 2 | **Data** | Real-time data streams<br>Batched data feeds<br>Aggregation |
| 1 | **Devices** | Sensors<br>Actuators<br>IOT Gateways |

Figure 4. Smart Park IOT Ecosystem

## 6.4 Devices layer

IoT devices fall into two main categories - sensors and actuators.

Sensors measure various parameters of the Smart Park environment such as temperature, water flows, people and traffic movement. Actuators on the other hand create events such as operating switches that turn on lights, pumps, mechanical motors and cameras. The activation of actuators can either be done remotely via the IoT communications network or the device may itself contain an embedded microcomputer which processes its data locally. A simple example is that of a gate opener.

The sensor supply market is already very well established and has been supplying businesses, particularly in industry, for several decades. Further development of sensors is accelerating rapidly due to the fast growth of demand in the IoT market. The latest innovations include miniaturisation such as the application of nanotechnologies and development of new sensing surfaces through bio-mimicry which is inspired by nature itself.

Some of the most recent developments involve the connection of sensors to the cloud providing more complete solutions and an exponential growth in design possibilities. These also enable new combinations of device capability. The many types of sensor include

- Temperature
- Pressure
- Humidity
- Flow sensors
- Accelerometer
- Magnetometer
- Gyroscope
- Inertial
- Image sensor
- Touch sensor
- Proximity sensor
- Motion
- Occupancy
- Light sensor
- Radar sensor

The important characteristics of devices in a Smart Park system are low power consumption, long battery life (if used), good communication range, and sufficient data transfer rates.

## 6.5 Data layer

An effective Smart Park system will not only rely on data gathered by in-park sensors, but will considerably enhance its overall intelligence by aggregating its own local data with that from many other sources such as national weather forecasting systems and satellite imagery. Data privacy and security need to be considered at the same time.

Big data, according to IBM[42], is being generated by everything around us at all times. Every digital process and social media exchange produces data. Systems, sensors and mobile devices transmit that data. It is arriving from multiple sources at alarming velocity, volume and variety. To extract meaningful value from big data, one needs optimal processing power, analytics capabilities and skills.

The Open Data Institute[43] (ODI) brings together commercial and non-commercial organisations and governments around specific sectors to address today's global challenges. The ODI helps people identify and address how the web of data will impact their businesses and their sectors, and together they are building a strong data infrastructure that delivers open innovation at web-scale.

New business models often rely on sharing and exchanging data between partner organisations to bring added-value to both.

Most open or commercially available data sources use standard protocols to enable efficient exchange mechanisms. Application programming interfaces (API) are built into the software solutions of both parties, for example, connecting a hotel's internal booking system to external online agencies such as Booking.com and Expedia.com.

Taking a holistic view of a Smart Park's internal and external data sources and how they are interconnected can help find opportunities for innovation with new data combinations. Much in-park data is held by external organisations such as Amazon, Google, TripAdvisor and mobile network operators EE, $O_{2}$,Three and Vodafone.

## 6.6 Connectivity layer

Efficient data connectivity is a critical success factor of an effective IoT infrastructure. It is in this aspect of a Smart Park that often many challenges lie, particularly in remote rural areas that are poorly served by both fixed line broadband and mobile network services. Many areas including those of national parks have very patchy coverage including

42 Big Data - IBM
43 The Open Data Institute

many ‘not spots’ with no connectivity at all. Faster services such as fibre-broadband and 4G are gradually being rolled out by individual telecommunications companies (telcos).

There is still a great deal of variation between networks whereby in specific spots one network may provide 4G, another only 2G and a third nothing at all. This causes a great deal of frustration for park visitors and residents, particularly when they find themselves in the wrong place for the network they subscribe to.

Radio spectrum allocation is normally controlled at national level by government agencies such as Ofcom in the UK. The technical standards that ensure network efficiency and interoperability of devices and data communication systems are generally set by alliances of telcos and equipment manufacturers. These are generally global in reach. A number of these alliances will be referred to in the rest of this section.

Machine-to-machine (M2M) technologies support communication between machines and devices through both wireless and wired systems. They represent one aspect of the IoT, namely that of connecting, monitoring, remote sensing and actuating devices. These also include local wired networks (LAN) and power-line communications (PLC) which use fixed wiring to simultaneously carry both data and electric power.

One of the leading alliances that underpins operation of the IoT is the M2M Alliance[44] which is a nonprofit, open membership association representing the interests of the Machine-to-Machine industry since 2007. Members include Telefonica, Three and Vodafone.

Data connectivity with devices placed in remote locations without fixed line Internet access have to rely on wireless technologies such as mobile phone networks or other radio links. These fall into two main categories: licensed and unlicensed spectrum. These are detailed below.

### 6.6.1 Licensed Spectrum

Licensed spectrum devices operate within the portion of the radio spectrum designated by Ofcom and reserved for telcos that have been granted licenses. With exclusive rights, a license holder is able to operate without interference or spectrum crowding.

In the UK the main telcos are EE (a division of the BT Group), O2 (owned by Telefonica of Spain), Three Group (subsidiary of CK Hutchison Holdings - Hong Kong) and Vodafone.

As well as the M2M Alliance mentioned earlier, the IoT World Alliance[45], a global partnership of telcos is dedicated to providing multinational customers with seamless M2M device connectivity around the world. Members include Telefonica.

New regulations introduced by the European Commission in 2016 have eliminated the additional costs of roaming between networks which is a key element of M2M networks and the future European Digital Single Market.

As an alternative, some companies are beginning to offer National Roaming (NR) SIM cards, e.g. Jump[46] card offered by 24Seven Communications.

Another development that will improve the reach of IoT in rural areas is that of narrow-band IoT (NB-IoT) which is a Low Power Wide Area Network (LPWAN) that enables devices that use lower data transmission to extend the reach of existing cellular networks. One such new service is that being developed by Vodafone and Huawei using lower frequency spectrum in the 2G range for low data transmission rates with longer range from radio mast. Other telcos developing NB-IoT service include EE utilising their 4G networks and Telstra[47] in partnership with Ericsson in Australia.

Control centre systems for managing large networks of connected devices are provided by, for example, EE and Cisco.

**The EE Connect Control Centre**[48] enables configuration of device SIM’s, monitoring of their activities and automatically adjusting their network services.

**Cisco’s Jasper Control Center**[49] provides management of large geographically dispersed networks of IoT devices using multi-provider mobile networks. Through a comprehensive real-time view

[44] M2M Alliance

[45] IoT World Alliance

[46] Jump - National Roaming SIM card

[47] Telstra - new kind of network

[48] EE Connect

[49] Cisco - Jasper Control Center

of the status of all devices it highlights any issues that may need to be addressed.

### 6.6.2 Unlicensed Spectrum

Many IoT devices use this radio spectrum, in which the Citizens Band also operates, as it is free to use without a Government controlled licence fee.

Power consumption is of particular concern where no mains electricity is available and devices have to rely on other forms of energy such as that from exchangeable batteries, or small solar panels and wind turbines with rechargeable batteries. The need for continuous or periodic data transmission has a major impact on power consumption. All these factors are taken into account in designing the IoT architecture for a particular application.

Some of the latest advances include the use of cognitive radio networks, such as xMax[50] from xG Technology. Cognitive radio technology is considered to be the next frontier in wireless communications. These radios are smart enough to make informed decisions on when and where to transmit, based on past usage and current conditions. They are designed with a high level of built-in intelligence and agility that enable them to adapt their characteristics to the operating environment, thus ensuring optimized transmissions and power consumption.

The unlicensed spectrum standards fall into two categories: Long range (up to 15km) and short range (up to 100m). Some examples of the main ones are provided below.

#### Long Range (unlicensed)

**LoRaWAN**[51] is a Long Range Wide Area Network. Its open source specification is intended for wireless battery powered devices. Operating at a regional, national or global network it addresses many of the requirements of the IoT, including secure bidirectional communication, mobility and localisation services. The specification aims to provide seamless interoperability among smart devices without the need for complex local installations. The range can be greatly extended by using each device as a receiver and transmitter of data to the next device in the form of a mesh network. Its open source structure allows independent developers to create networks of all sizes and degrees of complexity.

**Sigfox**[52] is a proprietary technology utilising a long-range ultra narrowband signal which requires little energy and forms a Low Power Wide Area Network (LPWAN). The network is based on one-hop star topology and requires a mobile operator to carry the generated data traffic. The signal can also be used to easily cover large areas and to reach underground objects.

#### Short Range (unlicensed)

**WiFi**[53] uses open spectrum for communication between personal computers, video-game consoles, smartphones, digital cameras, tablet computers, smart TVs, printers and many other Wi-Fi compatible devices. Local wireless networks can connect to the Internet via a wireless router or access point. Hundreds of companies from multiple industries collaborate within the Wi-Fi Alliance to drive the interoperability, adoption, and evolution of Wi-Fi globally.

The EU's WiFi4EU initiative, a part of the Digital Single Market, plans to set up wireless hotspots across the EU in 6-8,000 municipalities by 2020. It will support the installation of free public WiFi hotspots in local communities across the EU: in public squares, town halls, parks, libraries, and other public spaces.

**Bluetooth**[54] is a wireless technology standard for exchanging data over short distances from fixed and mobile devices, and building personal area networks (PANs). Invented by telecom vendor Ericsson in 1994 it is now managed by the Bluetooth Special Interest Group (SIG), which has more than 30,000 member companies in the areas of telecommunication, computing, networking, and consumer electronics.

The upcoming Bluetooth 5 standard will provide double the speed (2 Mbit/s), fourfold the range, and eightfold the data broadcasting capacity of transmissions compared to Bluetooth 4. The increase in transmissions could be important for IoT networks, where many devices connect throughout a whole building.

[50] Unlicensed Radio Spectrum (Business Insider)
[51] LoRa Alliance
[52] Sigfox
[53] Wi-Fi Alliance
[54] Bluetooth - Special Interest Group

**Z-Wave**[55] is a wireless communications protocol aimed at the home and office automation markets. The system can be controlled via the Internet with a gateway or central control device serving as both the Z-Wave hub controller and portal to the Internet. There are over 1,500 interoperable Z-Wave products marketed under different brands and over 35 million units have been sold since 2005.

**Zigbee**[56] through its low power consumption limits transmission distances to 100 meters depending environmental conditions. ZigBee devices can transmit over longer distances by passing data through a mesh network of intermediate devices to reach more distant units. ZigBee is typically used in low data rate applications that require long battery life and secure networking.

**6LoWPAN**[57] an acronym of IPv6 over Low Power Wireless Personal Area Networks, it was developed by the Internet Engineering Task Force (IETF). The concept originated from the idea that the Internet Protocol could be applied even to the smallest devices, and that low-power devices with limited processing capabilities should be able to participate in the IoT. It competes mainly with the Z-Wave and Zigbee protocols.

### 6.6.3 Hybrid Solutions

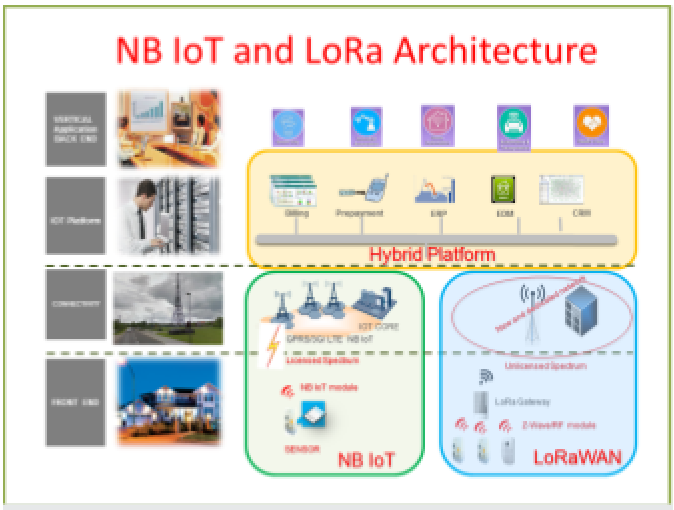



Figure 5. Hybrid NB-IOT and LoRaWAN Architecture

In some cases it may be necessary to place devices in areas with no mobile connectivity. Various hybrid solutions that combine different technologies may be possible, such as the potential solution architecture shown in the chart above (Figure 5) whereby separate NB-IoT and LoRaWAN networks share a common IoT platform which supports a range of vertical applications across the ten Smart Park dimensions.

## 6.7 IoT Platforms layer

Technology and business platforms are the core elements of a Smart Park ecosystem. Sangeet Choudary of MIT demonstrates in his book Platforms Revolution[58] how the power of the platform lies in new business models that use technology to connect people, organisations, and resources in an interactive ecosystem in which amazing amounts of value can be created and exchanged. Airbnb, Uber, Alibaba, and Facebook are just four examples from a list of disruptive platforms that includes Amazon, YouTube, eBay, Wikipedia, iPhone, Upwork, Twitter, KAYAK, Instagram, Pinterest, and dozens more.

McKinsey[59] broadly define a platform as software and hardware, which may include an operating environment, storage, computing power, security, development tools, and many other common functions. Platforms are designed to support many smaller application programs that actually solve business problems.

**IoT Platform Examples -** A selection of some of the main platform offerings is set out below.

### 6.7.1 Amazon AWS[60]

AWS IoT is a managed cloud platform that lets connected devices easily and securely interact with cloud applications and other devices. It can support billions of devices and trillions of messages, and can process and route those messages to AWS endpoints and to other devices reliably and securely.

### 6.7.2 Ericsson IoT Accelerator[61]

A platform for rapid IoT deployment, innovation and ecosystem collaboration. It facilitates acceleration of IoT deployments from concept through to commercial deployment. The IoT architecture includes marketplace and ecosystem enablement, orchestration, integration and automation as well as device and data management plus connectivity management.

55 Z-Wave Alliance
56 Zigbee Alliance
57 IETF - IoT Charter

58 Platform Revolution by S.Choudary (Amazon)
59 McKinsey - Making sense of IoT platforms
60 Amazon AWS IoT platform
61 Ericsson IoT Accelerator

### 6.7.3 Fujitsu MetaArc[62]

Fujitsu aims to create an environment to support innovation on a proven IoT platform, powering digital transformation with IoT solutions and services for the transformative enterprise. Their IoT solutions range from enterprise wearable devices, middleware software, cloud platforms to standardised business solutions for customer verticals. The MetaArc framework facilitates optimisation of the balance between Fast IT and Robust IT.

### 6.7.4 Huawei Ocean Connect[63]

Part of Huawei's cloud core network, OceanConnect is an IoT ecosystem with an IoT connection management platform as its core. Based on a unified platform, OceanConnect implements seamless connections between upstream and downstream product capabilities through open application programming interfaces (APIs) and serial Agent software. It provides peer-to-peer (P2P) high-value network applications (NAs) for customers, including Smart Home, Connected Car, intelligent meter reading (IMR), smart parking, and Safe City.

### 6.7.5 IBM Watson IoT Platform[64]

IBM Watson makes sense of data to help optimise operations, manage assets, reimagine products and services, and transform the customer experience. Recipes include control of drones, display of the status of registered devices, connection to an Intel IoT Gateway, and many others.

### 6.7.6 Intel IoT Platform[65]

The Intel® IoT Platform is an end-to-end reference model and family of products, which works with third party solutions to provide a foundation for seamless and secure connection of devices. The model delivers trusted data to the cloud, and on-going value through analytics.

### 6.7.7 Microsoft Azure[66]

Azure is built on the well established technologies of Windows Server, SQL Server, Active Directory, Hyper-V and others. This provides a consistent, familiar and stable environment. Virtual machines can be moved between on-premises and the cloud as often as business needs dictate – no conversion needed. It helps to protect business-critical applications with managed cloud backups and Disaster Recovery as a built-in service.

62 Fujitsu - Technology and service vision
63 Huawei - OceanConnect
64 IBM Watson IoT Platform
65 Intel IoT platform
66 Microsoft Azure

### 6.7.8 Oracle IoT Cloud[67]

New data-driven insights and actions from IoT are produced by connecting, analyzing and integrating device data into business processes and applications, enabling delivery of innovative new services faster and with less risk. The Asset Monitoring Application enables users working with both fixed and movable assets to perform tasks such as rapidly locating available assets for a job, assessing the health of their assets, and reviewing asset specifications while in the field or office.

### 6.7.9 ThingWorx[68]

ThingWorx is a complete, end-to-end technology platform designed specifically for the IoT. It empowers developers to connect, create, and deploy breakthrough, enterprise-ready IoT applications, solutions, and experiences.

## 6.8 Solutions layer

Applications or ‘apps’ for Smart Park end-users provide vertical solutions built on the functionality of the core IoT platforms. The vertical groups of applications are designed to address the requirements of specific industries such as hospitality and agriculture, professional such as lawyers and land surveyors or other user groups such cyclists and mountain climbers. These applications generally run on the commonly used desktop operating systems of Apple Mac and Microsoft Windows or smartphone and tablet device operating systems of Android and Apple iOS. These are generally made available through Apple’s ITunes Store, Google’s Play Store or Microsoft’s Windows App Store.

From stand-alone apps such tourist guides and weather forecasts to advanced apps connected to complex IoT systems providing desktop management dashboards and control panels, the Solutions layer effectively provides the main user interface to the Smart Park IoT ecosystem.

Each of the ten dimensions of the Smart Park model (section 4.3) can be effectively served by a vast array of applications.

The Smart Park solutions layer can be served by communities of developers who have been given

67 Oracle IoT Cloud
68 ThingWorx IoT technology platform

access to the park's software development kits (SDK). This infrastructure can support a growing Smart Park apps marketplace with new revenue streams involving developers, national park businesses and the national park authority.

## 6.9 Analytics layer

Devices in a national park already produce a great deal of data from many disparate sources. The analysis layer of the Smart Park IoT ecosystem will aggregate data from these and many new sources as IoT devices are deployed.

In addition to current methods of gathering and analysing park data, new developments in Data Science are creating advanced analysis tools using artificial intelligence (AI) and automated data processing to develop considerably more complex analysis with analytical models monitoring many more parameters, working at ever increasing speeds and providing much more monitoring data and detailed overviews that can be viewed by park supervisory staff in real-time. The IBM Watson[69] system provides such capabilities.

AI-enabled systems can produce notifications and alerts, or even trigger defined actions such as automatic emergency responses.

Some of the national park visitors already use AI-enabled systems such as those utilised by Booking.com and TripAdvisor. Another example is that of the Met Office[70] which is one of the UK's biggest users of supercomputing and artificial intelligence - all geared towards forecasting weather in the UK and around the world.

## 6.10 Cognitive layer

This brings new levels of understanding and helps build a comprehensive picture of how the Smart Park is operating as a whole. It helps to leverage the corporate knowledge[71] of the NPA and its partner organisations by combining human and machine learning. Experts from the NPA and its partner organisations are able to study and interpret the information provided by the Analytics IoT level (section 6.9).

The latest developments in augmented reality (AR) and virtual reality (VR) enable much enhanced interpretation by providing experts with the means to visualise new data in ways that are much easier and faster to absorb and to understand in greater depth. All of this will lead to better informed decision-making.

Virtual Reality (VR) enables information to be viewed in abstract or simulated form, even in some cases in tactile form.

Augmented Reality (AR) enables viewing of information in the context of the physical world by superimposing images and text on images or videos of the real world.

## 6.11 Intelligence layer

This is the layer that makes the park 'smart' or intelligent. It is in this layer that many of the most important benefits are generated through the connectedness of people using and managing the park. It can be viewed as a neural network that forms the corporate brain of the Smart Park.

It is at this level that one can bring meaning and sense-making to much of the data and information generated in the other seven Smart Park levels and create new actionable insights.

Park-wide IoT platforms form the core of the Smart Park. Through shared systems and services individual businesses will be able to operate more effectively than they can alone. Booking.com is already achieving this to some extent by helping improve hotel occupancy by directing potential customers to those establishments that at a given point in time have spare capacity.

Park-wide supply and demand modelling integrated with real-time consumer demand forecasting will enable new levels of effective resource planning and dynamic pricing to maximise asset utilisation for establishments such as attractions, hotels and restaurants.

The Intelligence layer will help to build the capacity for continuous innovation for the national park authority, its partners and other stakeholders. This enhanced creative capability will lead to new products and services, new operational efficiencies, new business models and associated revenue streams. Overall, it should enable the authority to further enhance achievement of its mission.

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[69] IBM Watson

[70] The Met Office

[71] Leveraging Corporate Knowledge (E.Truch)

# 7 The business case

## 7.1 Need for Innovation

In common with other public sector organisations, National Parks in the UK and abroad are under considerable pressure to 'deliver more for less'. Population growth and greater mobility are leading to increased numbers of visitors to national parks. This, in turn, is placing more pressure on the natural environment within the parks whilst climate change is creating additional challenges such as the flood events experienced in the last decade. Additionally, numerous organisations are striving to improve local emergency preparedness and community resilience.

As demonstrated by the use case examples in section 5, IoT can play a major role in meeting many of the above challenges as well as creating many new service enhancements that can deliver additional social and economic benefits.

## 7.2 New Opportunities

The rapid expansion of the IoT marketplace, described as a 'platform revolution' (section 6.7), is creating a vast array of potential solutions. In parallel, many of the barriers to development are gradually being eliminated by the following trends in IoT technologies:

- Rapid growth in availability of highly customisable IoT products and services
- Falling costs of IoT devices and systems
- Improved battery life of IoT devices in the field
- New IoT connectivity solutions

IoT has already arrived in national parks as a result of external market forces such as global booking and social media companies. The park authority and businesses within the parks have little or no influence over these trends other than participating in their development by, for example, placing their hotels in the booking database, often giving away substantial shares of their operating margins. Most feel that they are compelled to participate in order to survive financially.

For more of the potential benefits of IoT to accrue to parks and resident businesses it is necessary for them to take action to establish a more active role in creating and managing the opportunities created by new IoT technologies.

## 7.3 Identifying Potential Benefits

The enormous range of benefits that can be derived through the application of IoT technologies is clear to see from the many examples of implementation in virtually all sectors. The quantification and prediction of outcomes, including return on investment (ROI) in specific use cases is rather more difficult due to the flexibility of the technologies and resulting complexity of possible solutions. Traditionally, ROI estimates have focused simply on cash flows from cost savings and revenues from new products and services.

The complexity and extent of causal chains within an IoT-based system is clearly demonstrated by a Harvard University[72] study of smart road systems in San Francisco. They identified whole system impacts that go beyond shorter journey times and reduced traffic congestion to promoting better land use as car parking space is used more efficiently - eventually resulting in reduced pressure on urban land use and, hence, lower housing costs.

Whilst there are many examples of substantial gains in operational efficiency and often even more significant benefits from business transformation, it is difficult to translate them directly from one organisation to another due to the number of complicating factors involved. It is not a matter of simply installing technology. Success is highly dependent on a number of organisational factors such as internal policies and procedures, people skills and culture. All these need to be aligned to achieve optimal performance (see later section 8.1 on strategic alignment).

To identify and assess the potential benefits of IoT in a particular use case, it is necessary to have a good understanding of the underlying business model. One of the frequently used methods is that of the business model canvas[73] which includes the following nine dimensions: key partners, key activities, key resources, customer relationships, channels, customer segments, value proposition, cost structure and revenue streams. A variant of this model for public sector projects has been developed by Diaz-Diaz[74] and includes the additional dimensions of (i) social and environmental cost; and (ii) social and environmental benefit.

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[72] NY Times - How driverless cars could reshape cities
[73] Business model canvas (Strategyzer)
[74] Business model evaluation for smart cities (Diaz-Diaz et al.)

A successful low-risk approach to building an IoT-based business case is to focus on gaining approval for small scale prototyping and demonstration of potential gain in practical ways. This is why so many organisations that recognise the potential of IoT start with programmes of experimentation including in-house challenge events such as hackathons that bring together operational teams, application developers and IoT system providers in multi-day events in a creative atmosphere in order to invent new practical solutions that lend themselves to rapid evaluation and practical testing.

Traditionally most calculations of ROI resulting from the introduction of new technologies have focused on cost-reduction. When it comes to IoT other types of benefit need to be included in the ROI equation such as improvement in customer satisfaction and brand differentiation. Many businesses are beginning to appreciate this multidimensional nature of ROI and, in many cases, the cost-saving component has become secondary to the greater returns from other elements. For example, PTC[75], a global technology provider of IoT and augmented reality (AR) platforms, points to the need for new ROI metrics to capture the wide range of benefits that flow from IoT adoption. These include:

- **Reduction** in time to market, service costs, innovation time cycle, product recalls and returns, and call volumes in service centres
- **Increase** in market share, revenue, profitability/margins, customer satisfaction/loyalty, system up-times, and competitive advantage

In the absence of relevant quantified ROI studies of national park implementations a number of examples from other, but related, sectors are provided below. These demonstrate the scale and type of benefits that can be achieved through the introduction of IoT technologies.

**GE Power and Water** - provider of alternative fuel power generation equipment - increased up-time to save customers £1.0m; reduced onsite repairs by 50%; and saved £600,000 in customer service costs

**Varian Medical Systems** - manufacturer of scientific equipment - reduced their mean time to repair (MTTR) by 50%; 700 calls per month resolved remotely; and saved £1,500 for each problem resolved remotely

**Leica Microsystems** - producer of high-tech optical systems- reduced unscheduled downtime by 40%; cut field service visit by 33%; fixed 30% of detected problems remotely and saved more than £400,000 annually by avoiding 400 on-site visits

**Agilent Technologies** - provider of measurement solutions including chemical analysis, life sciences, and electronic measurement - increased deployments over a 2-year period by 450%; and reduced onsite repairs with no parts by 20%

Examples of disruptive innovations enabled by IoT technologies include those of Amazon, Booking.com and Uber, were mentioned earlier in section 6.7. All these have transformed the markets they operate in through the introduction of new business models.

## 7.4 Time for Action

Many of the ideas for IoT-based innovation have already been tried and tested in other national parks and smart cities around the world as can be seen from the use case examples in Section 5. The majority of these is already delivering tangible benefits within each of the ten Smart Park dimensions (Section 4.3).

Whilst the supply market for IoT devices and services is in a phase of rapid expansion, the development of the underlying technologies is settling down towards steady ongoing development and many reliable solutions are available. New supplier business models designed to encourage adoption offer reduced-risk options with incremental commitment such as:

- PAAS - platform as a service
- SAAS - software as a service
- PAYG - pay as you grow
- POC - proof of concept; no commitment until supplier has proved the concept through a clearly defined prototype

Delaying development of the Smart Park ecosystem is likely to negatively impact the future prospects of park-based businesses due to loss of competitive advantages over other visitor destinations and, from the park authority’s perspective, the consequences of falling behind with development of the visitor experience and meeting visitors’ ever growing expectations.

[75] PTC - IoT use cases

# 8 Getting from Here to There

The future vision of a Smart Park was presented in section 4 together with a 10-dimensional model. Each of these dimensions represents an existing element of today's national park that would benefit greatly from enhancement through the deployment of IoT technologies.

Reimagining a national park as a Smart Park requires one to think of a single IoT-enabled ecosystem with its many elements and stakeholders connected interactively in ways that enhance current ways of working. Resulting innovation can bring with it new benefits such as an improved visitor experience, effective sustainable transport, and growth of the local economy.

Achievement of the Smart Park vision would undoubtedly be aided by open discussion of the challenges and unrealised opportunities followed by a systematic review and identification of ways in which IoT can be deployed to address these and create new value-generating solutions.

Examination of examples from other national parks around the world can encourage new thinking about tomorrow's solutions and demonstrate the viability of these by presenting 'pockets of the future' taken from the continuous flow of early IoT adoption use cases identified and presented by IoT suppliers and market researchers.

Experience from major IT projects in recent years points to the benefits of incremental implementation whereby the risks of each stage are carefully managed. Project management and software development is commonly carried out in an agile[76] manner whereby the detail of each stage is reviewed and refined at the end of each preceding stage.

Many IoT technology companies supply their services through reduced risk contract arrangements such as platform as a service (PAAS) which can be scaled up or down as required. This avoids the risks often associated with large one-step projects requiring substantial capital investment upfront. Various payment models and risk sharing arrangements are available.

Thus it is possible to pilot small-scale prototype projects with relatively small resource commitment and to later scale up when conceptual designs have been tested and proven to be successful. Another benefit of this low risk approach is that it allows greater freedom for innovation.

In reality, most national park organisations are already making use of IoT technologies and solution, including email, business websites, and social media which are in many cases deeply embedded in their operations. It is hard to imagine how these organisations could function without them.

One of the main challenges may be that of persuading businesses to adopt common technical standards and to share IoT platforms and data in order to achieve high levels of systems integration and all the benefits that flow from such collaborative arrangements. Again, this has already been achieved to the extent that accommodation providers have aligned their booking systems to online agencies such as Booking.com, Hoseasons and Sykes Cottages. Either their in-house systems are integrated and exchange occupancy data in real-time or they have transitioned entirely to using their agents' systems instead.

### Encouraging Innovation

Demonstration of feasibility is probably best done by involving organisations in small prototype projects that have the potential to develop into fully operational models for their businesses. One such approach is through hackathons which are becoming an increasingly popular and successful way of stimulating innovation. An example of this approach is the Smart Park Hackathon[77], already mentioned earlier in Section 3, organised in 2017 by the National Park Research Centre (now part of CCRL), Lancaster University Management School.

During the intensive two-day event postgraduate student teams, supported by national park and technology experts, created product concepts such as the following:

- sustainable multimodal transport to enhance the visitor experience
- a safety-enhancing smart sensor attached to a bicycle
- a holistic IoT solution integrating multiple sensor types linked to augmented reality and gamification to create an interactive visitor

[76] Agile project management (Lynda.com)

[77] Smart Parks hackathon video

experience (aimed at attracting younger park visitors)
- another app for attracting younger people which includes treasure hunts and orienteering with prizes that promote visits to local attractions and eateries
- an IoT design (Smart Path) for detection and prevention of erosion of hiking paths by providing analysis and recommendations for damage prevention and maintenance optimisation.

Liam McAleese, Head of Strategy at the LDNPA, stated "The process was very creative and dynamic. It led to presentations at the end of the two-day event that were really quite different and provided potentially business-ready propositions."

## 8.1 Design Considerations

Both the complexity of IoT architecture and the fast-evolving supply marketplace pose particular challenges when designing, sourcing and implementing a comprehensive IoT programme.

Some of these can be addressed by adopting an incremental approach to system building with an agile project management approach. One of the first key decisions to be taken will be the choice of IoT platform. Fortunately, many vendors are willing to support prototyping of new solutions and can make their platforms available for piloting and testing. From that point on, various flexible payment plans are available.

It is worth drawing on the experience gained in developing Smart Cities as there are so many similarities both in the technologies employed and the solutions created. The British Standards Institute has published two publicly available specifications (PAS) for Smart Parks:

1. PAS 181 - Smart Cities Framework[78]. Guide to establishing strategies for smart cities and communities

2. PAS 182 - Smart City Concept Model[79]. Guide to establishing a model for data tackles the barriers to implementing smart city concepts.

**Strategic alignment -** One of the critical success factors of IoT systems is the degree of alignment between the IoT system design and the client organisation's strategy, people and processes. Various studies have demonstrated the importance of strategic fit[80] in delivering superior performance.

The adoption of new technologies often requires new people skills and revision of internal processes in order to gain most benefit from the new systems. This can clearly have an impact on project costs and timeframe.

**Regulatory framework -** The implementation of IoT devices such as cameras and drones is subject to frequently changing regulations and what may be permissible today may not be tomorrow. This is a risk that needs to be well understood and taken into account when designing an IoT system that may contain such components.

A salutary example of overzealous use of new technologies is that of smart bins[81] used in the City of London in 2013 for collecting mobile phone data from passers by. This turned out to be a grey area in the law and the smart bins had to be removed.

**Future proofing -** It is important to select providers carefully with assurance of continuous development to meet changing requirements and to maintain compatibility with continuously evolving technologies. This is particularly challenging when a product's life is shorter than the time required for payback on investment. This needs to be reflected in procurement policies and can sometime be mitigated by risk-sharing arrangements with the vendor.

Open standards and standardised solutions from well-established major providers are generally safer and more sustainable than tailor-made solutions. Other important considerations include the need for robust security measures as set out in a recent McKinsey report[82].

When budgeting for an IT system one should consider the total cost of ownership (TCO). Cost calculations should include regular system upgrades, ongoing maintenance, business continuity for mission critical systems, and disaster recovery measures.

[78] BSI - Smart City Framework (PAS 181)
[79] BSI - Smart City Concept Model (PAS 182)
[80] Importance of Strategic Fit (E.Truch)
[81] Smart bin deployment in London 2012
[82] McKinsey - Security in the IoT

## 8.2 Development Roadmap

### Future Scenarios

In order to explore development options and envision the creation of a Smart Park a number of potential future scenarios have been developed. Based on the two key uncertainties, namely the degree of IoT adoption (shown on the vertical axis) and the degree of systems integration (horizontal axis), four distinct future scenarios are identified.

### Scenario A - Baseline

Some IoT systems already adopted sporadically by organisations, or being used by visitors such as the many smartphone apps. These include use of e.g. Google Maps for navigation, Ordnance Survey apps, and Chimani from the USA who have now launched an English Lake District app (Section 5.6.2).

### Scenario B - Independent

In this fragmented scenario organisations have adopted IoT technologies independently utilising different technical standards and with a reduced level of interoperability between systems. These include stand-alone network solutions internal to the organisation such as WiFi, Z-Wave. Examples include premises security and wireless handheld payment terminals.

### Scenario C - Connected

Common IoT infrastructure. Interoperability ensured by commonly adopted standards and central IoT platform managed by the NPA. Other organisations use their own solutions which utilise the park IoT platform.

### Scenario D - Smart Park

This represents a fully integrated and functional Smart Park with a central IoT platform as in Scenario C and which enjoys many if not all the benefits of new revenue streams, additional efficiencies, cost savings, enhanced management information systems, increased capabilities across many operational areas that enhance delivery of the Park's mission. Besides the common functional elements with shared analytics and intelligence, there is room for independent development for organisations who do not actively participate or wish to follow later.

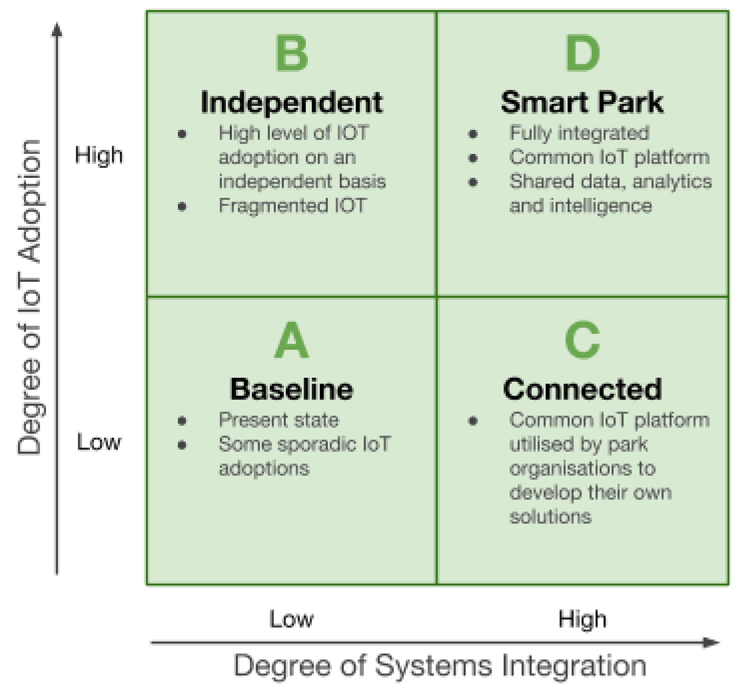


Figure 6. Smart Park Future Scenarios

### Comparing Scenario Characteristics

The table below (figure 7) sets out the Smart Park features for each of the four scenarios.

At present, most of the park organisations are in the baseline scenario, with very few organizations in the independent scenario. If many more organizations pursue the independent scenario, there will be pockets of innovative solutions that are highly fragmented and likely to confuse the park visitors.

| IoT Ecosystem | A Baseline | B Independent | C Connected | D Smart Park |
|---|---|---|---|---|
| Generally available apps, with varying degrees of customisation | ✓ | ✓ | ✓ | ✓ |
| Access to shared communication networks | | ✓ | ✓ | ✓ |
| Shared data from National Park sensors | | | ✓ | ✓ |
| Use of common IoT platforms | | | ✓ | ✓ |
| Big Data analytics; business intelligence, AI, process automation | | | | ✓ |
| Advanced park-wide IoT platform development | | | | ✓ |
| New and shared revenue streams | | | | ✓ |

Figure 7. IOT in Smart Park Future Scenarios

The benefits of the fully integrated Smart Park scenario include the following:

- More innovative solutions as they can be connected to many more sources of data and analytics capability
- Greater economies of scale
- Improved asset utilisation through sharing and resource smoothing
- Joint yield management
- Increased purchasing power and stronger negotiating position

## 8.3 Development route options

In order to better understand the possible development paths that can be taken, two main routes have been identified. They are described below and illustrated in Figure 8.

**Route 1 - Managed growth**
Park Authority, initially alone or with a small number of partners, establishes core IoT platform and supporting systems; pilots a number of pathfinder projects;  and demonstrates economic viability. The growth will continue from Scenario C (Connected) to fully integrated Smart Park (Scenario D).

**Route 2 - Organic growth**
Park organisations move to Scenario B with comprehensive IoT adoption but in independent and fragmented ways.

### Comparison of route options

**Route 1** is the more certain of the two in terms of achieving the Smart Park vision and its associated benefits in a more timely and coherent manner. Against that the additional effort to develop a more detailed model, set common standards and coordinate adoption across a large number of players will not be insignificant.

**Route 2** will have the distinct challenge in that it is likely to mature in Scenario B and not progress beyond that to the fully integrated Smart Park (Scenario D). The transition from Scenario B to Scenario D is likely to be very difficult if not impossible. Organisations in Scenario B will be less willing to switch systems and vendors to migrate to Scenario D. Such a move would inevitably incur considerable costs and potential business disruption.

There exists a 1-2 years window of opportunity between now and before the majority of businesses move towards scenario B. After that it will become increasingly difficult to achieve Scenario D.

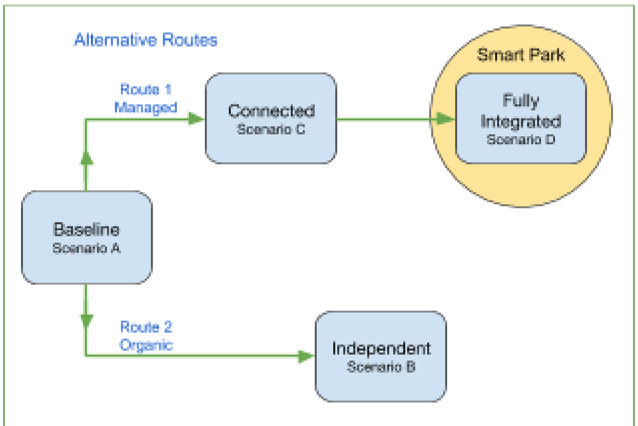


Figure 8. Smart Park Development Roadmap

In conclusion, achievement of the full Smart Park model requires Route 1.

# 9 Conclusions

Today's national park already enjoys widespread use of IoT although it is not generally recognised as such. Most visitors are already using smartphone apps such as those from Google, Ordnance Survey, Booking.com and TripAdvisor for navigation, booking accommodation and restaurants. Social media apps are also widely used. All of these come under the umbrella term 'Internet of Things'. Additionally, many commercial applications are in use, such as those used by the Environment Agency for monitoring and controlling river levels, and Amazon for distribution of goods.

As development of IoT technologies and wireless connectivity continues at a pace, it brings a whole new wave of opportunities that could substantially benefit any national park across all ten Smart Park dimensions (section 4.3) from tourism and transport to communities, environment and nature.

Some applications will continue to develop organically through businesses acting independently and responding to general market trends.

To maximise the benefits of IoT for national parks, a joined-up fully integrated approach is urgently required. Otherwise, companies external to the Park, such as Booking.com and Expedia, will continue to reap many of the economic benefits which might otherwise be enjoyed by local businesses.

All people, including park visitors, should be seen as producers as well as consumers of data. Visitors' opinions (ratings) and internet browsing histories enable predictions of future behaviours such as online purchasing and recommendations of in-park activities. This can become part of an ongoing value exchange.

The development of the next generation of IoT functionality that achieves the vision of a fully integrated Smart Park will require a common centrally managed IoT platform that will support a comprehensive, coherent and connected approach to creating and sharing park-wide business intelligence and a new ecosystem of products and services that benefit all park stakeholders.

The Smart Park Intelligence layer brings so much more with it and opens up a whole raft of additional opportunities.

Creation of a fully integrated Smart Park (scenario D in section 8.2) will be considerably more difficult if businesses have already developed their own IoT capabilities independently, probably based on differing standards, as represented by scenario B. The costs of switching and the natural resistance to move to new solutions and providers will likely lead to generally missing the opportunities that realisation of a fully functioning integrated Smart Park vision would bring.

Pockets of the future, as found amongst the examples identified in the report, demonstrate what is possible and confirm the new IoT-enabled opportunities that are worth pursuing and have the potential for delivering considerable benefits to all national park stakeholders.

In summary, the opportunities are considerable and the time to act is now.

### Next steps for Park Authorities and Partners

Successful implementations of IoT systems tend to include the following four elements:

1. **Strategy** development that addresses (a) internally, the needs of the park authority such as land planning and management, people movement, preservation of nature and wildlife; and (b) externally, the needs of partners and stakeholders such as residents, tourists and businesses

2. **Management capacity** necessary for overseeing development and implementation of smart park programmes. This can be achieved in collaboration with research partners, consultancy firms, technology providers and systems developers

3. **Standards** that provide a common base for parallel development of discrete elements of the overall smart park system. This might include adoption of relevant elements of BSI standards PAS 181, 182 for Smart City good practices with particular reference to the checklist for critical success factors (appendix B)

4. **Innovation** inspired through pilot projects, showcasing of successful implementations and organising events that bring together designers, developers and end-users to create new solutions. This could be in the form of an Innovation Hub that runs hackathons and other creative challenges.

# Connected Communities Research Lab

Our programme of interdisciplinary research explores the mechanisms underlying the functioning of communities of people and things. Our Smart Parks research programme is exploring the application of IoT in natural environments such as national parks and urban green spaces. The broad range of activities includes conceptual development of theoretical models, their operationalisation in multiple contexts, action research, and organisation of innovation events such as hackathons that bring together end-users, technology providers, system developers, sector experts, and postgraduate students.

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www.connected.community/smart-park

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