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OLD OAK AND
PARK ROYAL
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CORPORATION

HYPERCAT

OLD OAK & PARK ROYAL



SMART STRATEGY REPORT

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A. EXECUTIVE SUMMARY

A. EXECUTIVE SUMMARY

The Old Oak & Park Royal Development Corporation (OPDC) is being supported by Hypercat to develop its Smart Strategy to inform the draft OPDC Local Plan. This is the second and final version of the Smart Strategy and has been amended to include topics not previously included relating to the circular economy, green infrastructure and social infrastructure.

Hypercat carried out thirty-seven workshops across six domains bringing together over 300 experts from a wide range of industries, academia and government. These workshops were used to crowdsource information and captured a wealth of information on how existing and future technologies, digital systems and/or other smart city solutions and approaches could transform Old Oak & Park Royal into a global leading location where people would want to live, work and visit.

The six workshop domains were:

1. Access to data
2. Clean and green environment
3. People centric cities and community services
4. Smart utilities infrastructure
5. Safe and smart transport
6. Smart energy

Each workshop explored perceived views of what 'smart' may look like in improving the planning, delivery and management of Old Oak and Park Royal. This presented an efficient way to capture a variety of ideas, challenges, opportunities and use cases where technology and digital systems have been demonstrated and/or are taking an innovative or intelligent approach to solve problems.

This report represents the findings of the workshops which relate to the local planning process. The findings are presented as the following themes:

1. Transport and public realm
2. Utilities infrastructure
3. Smart sustainability
4. Commercial uses and health infrastructure

The opinions of the participants are presented and grouped into key elements, opportunities and challenges. These have then been matched with relevant use case studies to deliver a series of initial recommendations for the draft Local Plan.

In summary, Old Oak and Park Royal should seek to promote and utilise innovation to become a world-leading location for the exploration and implementation of smart city technology, digital systems and other approaches to support economic growth, enhance the environment and improve the quality of life for local people and visitors. Some of the key recommendations include using technologies and digital systems to:

1. Be green
   a. Support the circular economy and minimise waste generation.
   b. Actively mitigate and adapt to climate change.
   c. Improve air quality.
   d. Intelligently manage energy networks that generate cleaner energy.
2. Be integrated and connected
   a. Use the public realm and buildings efficiently.
   b. Integrate management of transport network capacity.
   c. Improve and establish world-class digital connectivity.
   d. Personalise wayfinding and enable people to easily move and access places.
3. Be innovative
   a. Nurture innovation.
   b. Explore and implement appropriate deliverable solutions.
   c. Encourage collaboration and sharing.

1.0 INTRODUCTION

1.1 WHAT IS THE ROLE OF THIS DOCUMENT?

The Old Oak & Park Royal Development Corporation (OPDC) is being supported by Hypercat to develop its emerging Smart Strategy. The Smart Strategy is being developed to primarily support the emerging OPDC Local Plan, but it will inform other OPDC strategies and activities. This Smart Strategy should be read alongside the Smart London Plan.

This report sets out a recommended smart vision and objectives, supported by a series of identified key elements, opportunities, challenges and potential use cases for key themes and provides recommendations for the draft Local Plan policy. The key themes are:

- Transport and public realm
- Utilities infrastructure
- Smart sustainability
- Commercial uses and health infrastructure

1.2 RELATIONSHIP WITH THE SMART LONDON PLAN

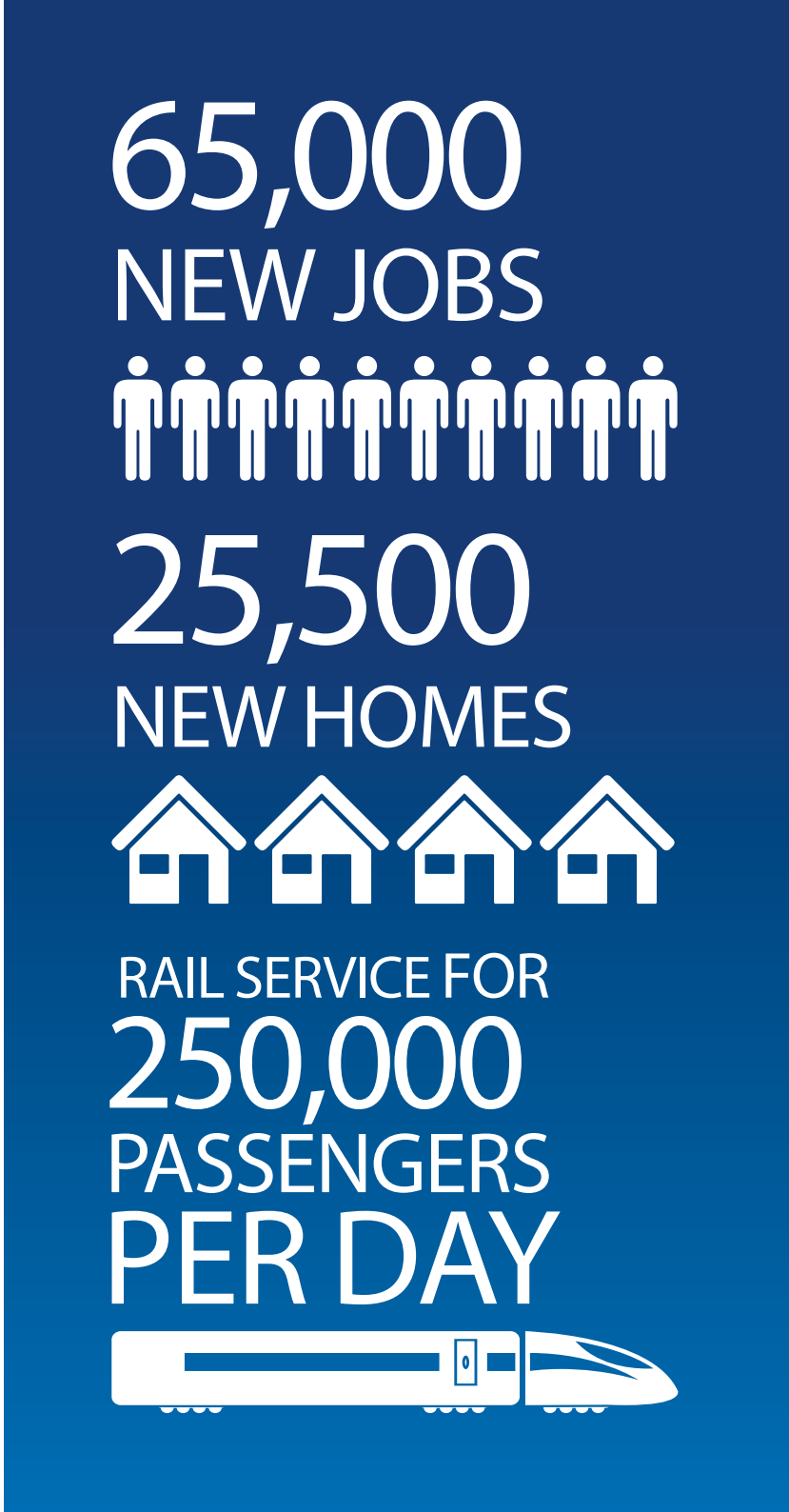
The Mayor of London published the Smart London Plan in 2013. It sets out the vision for helping the capital to function, support its growth and help infrastructure and services to be more responsive to Londoners and business needs. This report has been informed by the Smart London Plan.

1.3 WHAT ARE THE OPPORTUNITIES AND CHALLENGES PRESENTED BY OLD OAK AND PARK ROYAL?

The rapidly emerging range of technologies and concepts within the smart city technology sector alongside the establishment of the Old Oak and Park Royal Development Corporation (OPDC) to drive the regeneration of Old Oak and Park Royal provides an unparalleled opportunity to embed smart city technology and approaches within the DNA of the area.

The regeneration will create space for 65,000 new jobs, deliver a minimum of 25,500 new homes and will be supported by a range of physical, social and green infrastructure. At the heart of the area will be the new Old Oak Common Station that will serve 250,000 passengers per day and will be akin to Waterloo Station in terms of size and Kings Cross St. Pancras in terms of regeneration opportunity. Each of these components required to deliver a new part of London represent potential opportunities for new technologies and innovative approaches for their planning, delivery and management to be explored and implemented that benefits the local area, communities and the local economy.

While the delivery of new homes and jobs within Old Oak and Park Royal represents significant benefits for west London, it also poses a number of specific challenges. Alongside this growth, more extreme weather conditions and the need to minimise the use of resources, will place additional requirements on infrastructure networks and the need to design and utilise urban spaces and buildings more efficiently. Smart city technologies and non-traditional methods have the potential to help address these specific issues and other broader challenges facing urban areas.



1.4 EXPLORING DEFINITIONS

Bringing together over 300 experts from a wide range of industries, academia and government, Hypercat explored through a crowdsourcing process what smart is considered to be for Old Oak and Park Royal.

'Smart' as a general concept can be considered to be about actively understanding and accessing knowledge, expertise and technology across sectors and the linkage between them. Urban challenges are interconnected and need to be analysed as a whole interactive system rather than mitigating and resolving them in silos. Implementing a smart approach can assist formulating policies that are likely to drive up performance and efficiencies in services, whilst delivering lower operational and maintenance costs.

'Smart' approaches should also aim to address a wide range of health, social, economic, and environmental issues to create a place where people would want to live, work and visit. This place should be inclusive, attracting a diversity of people who can afford to function in Old Oak and Park Royal at a domestic, commercial and personal level, and importantly, feel part of a 'connected' community. The area should accommodate people with varying needs and vulnerabilities, and be safe and clean thus contributing to the 'well-being' or 'healthiness' of the community. 'Smart' approaches should also aim to ensure that Old Oak and Park Royal is well connected to other parts of London, the rest of the UK and beyond.

Although technology is a tool that can help urban areas to address challenges and meet their needs, alone it is not a solution to urban challenges but an enabler. Technology is continuously changing with its own intrinsic limitations which needs to be assessed and addressed. Despite limitations, technology provides multiple benefits. Digital technologies or information and communication technologies (ICT) can automate operations and processes, and provide access to real-time information that can lead to immediate actions. This aids greatly in controlling risks and threats, keeping down costs and resource consumption, improving the quality and performance of public services, and communicating effectively with the people. To see the full benefit, it is crucial that technology is embedded in city development in a flexible and scalable way. This flexibility will allow technology to be upgraded and improved over time in response to the changes in the challenges that cities seek to address.

The 'Internet of Things' evolution is furthermore creating innovative and interoperable ways to drive efficiencies across all of these desired outcomes. Interoperability provides a tremendous opportunity to look at urban areas as a whole system rather than in silos. Interoperability allows different data and systems to work together and exchange information within or across organisations and supply chains, providing a realistic and interconnected view of the urban ecosystem and its problems, which can be addressed accordingly. 'Smart' approaches to urban development should therefore consider interoperable standards and technologies to drive efficiencies and lower costs.

The consideration of these elements shapes the draft smart vision for Old Oak and Park Royal, which is defined in section 3.0.

2.0 METHOD

2.1 WORKSHOPS AND ATTENDEES

Hypercat facilitated a series of 37 workshops, crowdsourcing activities and focus group interviews to gather participants' perception of what 'smart' may look like for Old Oak and Park Royal.

Specifically, this was carried out in the context of planning, delivering and managing cities across interconnected thematic areas and how technology, digital systems or other approaches can best aid the process. The 37 workshops were organised across six thematic areas including:

1. Access to data
2. Clean and green environment
3. People centric cities and community services
4. Smart utilities infrastructure
5. Safe and smart transport
6. Smart energy

Five to seven workshops were organised per thematic area. Each workshop had a specific topic for discussion and explored perceived views of what 'smart' may look like in improving the planning, delivery and management of Old Oak and Park Royal. Participants were also asked to think about how 'smart' technologies, systems and/or other methods can drive efficiencies across public services delivery and use of resources; empower citizens and communities; foster innovation and economic growth; and induce positive change. While not intended to be a representative sample, there was an attempt to balance groups by gender.

The intent was to gather information about demonstrable technologies, systems and other solutions from experts from different sectors. Crowdsourcing and focus group interviews presented an efficient way to capture a variety of ideas, challenges, opportunities and use cases where technology and digital systems have been demonstrated and/or are taking an innovative or intelligent approach to solve problems. This approach allowed us to gather perspectives about social, economic, environmental and regulatory issues and opportunities from over 300 people.

Outputs from previous events relating to smart cities and Old Oak and Park Royal have also informed the development of this report. Appendix 1 provides a list of participating organisations, from which different individuals with varying backgrounds and expertise took part in the workshops.

2.2 DATA COLLECTION AND ANALYSIS

Workshops were held at the Hypercat office at the Future Cities Catapult between September and October 2015, and averaged two hours with a break. The groups contained eight participants on average and were moderated by a Chair/Moderator.

Workshops were recorded with data subsequently analysed to look for emerging themes, challenges, opportunities and use cases for each topic of discussion. The emerging themes from workshops were also compared to assess any cross cutting information for similarities and differences between them. The content presented in this report only looks at key themes to inform the OPDC draft Local Plan. As such, this report is based on an analysis of the opinions of experts in a wide variety of fields relating to smart cities.

3.0 RECOMMENDED SMART VISION AND OBJECTIVES

3.0 RECOMMENDED SMART VISION AND OBJECTIVES

Following the review of extensive discussions across workshops, a recommended smart vision and set of objectives have been proposed. While primarily for the purposes of the draft Local Plan they have also been developed to help inform the wider OPDC activities.

3.1 RECOMMENDED SMART VISION FOR OLD OAK AND PARK ROYAL

Old Oak and Park Royal should promote and utilise innovation to become a world-leading location for the exploration and implementation of smart city technology, digital systems and other approaches to support economic growth, enhance the environment and improve the quality of life for local people and visitors.

3.2 RECOMMENDED SMART OBJECTIVES

OPDC should deliver the vision by optimising the use of smart technology, digital systems and approaches to:

1. Address challenges in regenerating the wider area while creating and capturing opportunities;
2. Plan, deliver and manage Old Oak and Park Royal effectively and efficiently to be green, connected, integrated and innovative; and
3. Help to inform OPDC activities and strategies.

4.0 KEY THEMES

4.0 KEY THEMES

The key themes presented in this report are:

1. Transport and public realm
2. Utilities infrastructure
3. Smart sustainability
4. Commercial uses and health infrastructure

For each theme the following information is provided:

- Overview – defines the theme and sets out the specific elements.
- Specific elements – sets out key elements, challenges, opportunities and use cases for each specific element.

4.1 TRANSPORT AND PUBLIC REALM

4.1.1 OVERVIEW

The success of Old Oak and Park Royal as a sustainable place where people live, work, play and visit is heavily influenced by the quality of the transport infrastructure and the public realm. People need to be easily connected to destinations within and outside of Old Oak and Park Royal.

The public realm plays a key role in supporting this movement and in functioning as a space where people can relax, work, socialise, play and enjoy. These elements need to be supported through connectivity, not just in urban design terms but also through digital connectivity and the provision of information.

This section highlights the perceived key challenges and opportunities for local planning in improving elements of the transport network and the quality of the public realm. It presents the findings of how technology and digital systems can inform the following specific elements to:

1. Public realm
   Shape the design, delivery and management of the public realm including highway design and car parking.
2. Navigate
   Help people to navigate around Old Oak and Park Royal.
3. Freight, waste and construction transport
   Enable smooth transport of freight in and out of Old Oak and Park Royal including construction materials and associated waste.
4. Stations
   Help with the design, planning and management of stations to integrate them into the wider built environment.

4.1.2 PUBLIC REALM

The quality of the transport modes and the public realm play a vital role in helping people to make smart travel choices to move within and beyond an urban neighbourhood.

The design, delivery and management of the public realm – including, publicly owned streets, parks, pathways, open spaces and buildings – has a considerable impact on its residents, businesses and visitors, because it acts as glue that connects people to their social networks and other residential, commercial, educational and recreational uses.

To improve the development of the public realm to create an environment where people would want to work and live, while supporting the economy, requires a clear understanding of market and technology developments, social trends and needs, innovative approaches of using space, and the role of data and analytics in providing people with up-to-date information. Table 1 highlights the key elements, challenges, opportunities and use cases for public realm.

TABLE 1. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR PUBLIC REALM

Key elements	Key opportunities	Key challenges	Use cases
Efficient use of public realm	Dynamic street markings to facilitate shared use of public realm On street flexible parking spaces and responsive road markings (including cycle lanes) could be used to accommodate variations in real-time demand and support the delivery of autonomous vehicles to provide additional public open space.	Dynamic street markings and use of space Changing the demarcation of road markings to switch dynamically will need to be considered in the early detailed design of the movement network and in coordination with TfL. There is a need to understand what risks may be associated with failures, weather disruptions and uncertainties. Future-proofing the delivery of technology and utilities infrastructure Understanding how the delivery of technology and digital communications infrastructure can be future proofed by considering longevity of infrastructure will help to minimise disruption to public realm. However, this will need to be considered in the early detailed design of the movement network.	Responsive Bike Lanes Consider following the Smart Oxford Challenge. Oxford's medieval urban structure makes it costly and difficult to introduce large scale infrastructure projects. The city has a large number of cyclists sharing busy roads with buses and taxis, increasing safety risks. Their 'Responsive Bike Lanes' project aims to create street lanes and road signage that responds to an influx of cyclists, prioritising bikes over cars at peak times. This project is in the very early days of development.

TABLE 1. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Managing and using Internet of Things technology	**Embedding technology** Embedding sensors, digital communication infrastructure and automated mechanisms within the public realm could provide real-time navigation information, cycle parking information and deliver information to support the management and use of spaces, buildings and infrastructure. **Localised energy generation** Use of kinetic energy storage within the public realm generated by movement could help to contribute to sustainable energy targets.	**Managing Internet of Things technology** Implementation and use of sensors must ensure information collected is secure. Technologies utilised will need to be flexible in their use, have a long-life cycle and with low maintenance needs to help manage the creation of electronic waste. **Allow for flexibility & scalability** Technology is likely to change and improve over the next decades so create a flexible and scalable way to install new parts, change existing ones and/or remove them.	**Queen Elizabeth Olympic Park** The London Legacy Development Corporation is currently utilising sensors to aid in the management and future planning of the Queen Elizabeth Olympic Park. **SFpark System, San Francisco** This system has made it easier for drivers to find parking, reduced vehicle miles travelled, increased net parking revenue, and decreased greenhouse gas emissions. **Pavegen** Pavegen tiles generate power from pedestrian movement. An existing example can be seen at Heathrow Terminal 3 where movement is used to power LED lights. Other examples at: SNCF, Paris; Shell Football Pitch, Rio de Janeiro; Kia Motors, South Korea; West Ham Tube Station, Olympics 2012, London.
Autonomous Vehicles (AVs)	**Accommodating AVs in the public realm** The design, delivery and management of the public realm could take into account the impact of AVs. This may result in public realm and movement networks to accommodate a greater amount of flexibility to support additional space for walking, cycling and leisure activities.	**Accommodating AVs and supporting infrastructure** AVs will likely require innovative methods for storage, access and refuelling that will disrupt the conventional approach to parking and public realm planning. However, the AVs sector is currently in its infancy and it is unclear whether the future will be dominated by genuinely driverless cars, an increasing level of automation of conventional cars, or new modes such as Personal Rapid Transit. Similarly, vehicles may be driver-owned, communally owned, operated for hire, or operated as public transport.	**Autonomous vehicle trials** The autonomous vehicle trials currently underway in Milton Keynes, RB Greenwich and Bristol are beginning to explore how the roll-out of autonomous vehicles will impact the public realm.

4.1.3 NAVIGATING AROUND OLD OAK AND PARK ROYAL

A growing urban area presents specific challenges for its inhabitants.

At Old Oak and Park Royal, the long-term development period and the resultant dynamic mix of uses could make it difficult for people to find their way to key destinations and public transport hubs. While establishing an accessible and legible environment is a critical component of the draft Local Plan, it can be supported by existing and emerging smart city technologies to help plan the area and help people navigate. Table 2 highlights the key elements, challenges, opportunities and use cases for navigation.

TABLE 2. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR NAVIGATION

Key elements	Key opportunities	Key challenges	Use cases
Movement modelling	**Virtual spatial layout & accessibility modelling methods** Use of design-based existing methods, such as by Space Syntax, and emerging methods, such as those using de-sensitised data from Internet of Things sensors and software to understand how best to shape the urban fabric to support movement and placemaking, as well as to gain economic, social and cultural value from public open spaces. These methods offer the potential for existing and future barriers to movement to be addressed in order to enable accessibility for all. **Intelligent & digital signage** Use dynamic, intelligent and digital signage, which responds to conditions, to help people move and make decisions about movement.	**Spatial layout & accessibility** Efficient navigation requires a good spatial urban layout which takes into account movement across various locations and the best linkage between them, in addition to technology. **Signage: static vs. variable digital** Digital signage needs to be balanced with fixed analogue signage as some people will still rely on them and it will be in need during power outage.	**Space Syntax** Uses an established and recognised space-based modelling approach to plan and design buildings and cities: - Victoria Station project: showed that pedestrian movement is critical to business performance in London. - London Legacy Development Corporation, London Olympic Park Legacy project: used spatial modelling techniques to promote connections between it and the surrounding areas. - Many other examples in the UK and globally. **Legible London** It is TfL's signage system that provides street-level maps and directional information to help people find their way by walking. It has achieved a high level of approval.

TABLE 2. (continued)

Key elems	Key opportunities	Key challenges	Use cases
Movement modelling	Access to personalized information Users' needs for travel guidance could be met through up to date public online information and accessed through applications. Knowing the users and their needs Consider understanding users' need including the provision of apps with user specific information. Cycling Consider making cycling in the area easier and safer, and integrate it with other transport hubs.	Information about the wider transport network Public navigation tools should inform about the status of the wider transport network; this is currently limited. Knowing users and their needs Consider the needs of different users in developing navigation and wayfinding tools including needs of vulnerable populations.	Citymapper An application that uses various types of data to allow people to find the best route to their destination. Area 360 Location It enables organisations to customize the way visitors discover, connect and share what's around them through the use of indoor wayfinding technology. Maynard Design Innovative fixed and digital wayfinding for the Queen Elizabeth Park.
Personalized wayfinding and navigation	Fixed & digital signage Use of dynamic, intelligent and digital signage, which responds to environmental and street conditions and public realm networks, could help people to navigate and make decisions about movement. Access to ubiquitous personalised information Users' needs for travel guidance could be met through up to date public online information, accessed through applications. Although this is currently available at present, it could be further refined at a micro level and with environmental data such as air quality information. Sharing transport local data Sharing transport data securely with third-parties to deliver solutions can also help to support economic growth. Augmented reality Offers a potential opportunity to integrate digital navigation technology with static elements through wearable technology.	Fixed vs. variable digital Digital signage needs to be balanced with fixed analogue signage to accommodate visual accessibility and resilience. Knowing users and their needs Understand the challenges for considering the needs of different users in developing navigation and wayfinding tools including needs of vulnerable populations.	Legible London TfL's signage system provides street-level maps and directional information to help people find their way by walking. It currently relies on static signage but could be enhanced with digital elements. Citymapper A smartphone app that aggregates various types of transport data to allow people to find the best route to their destination. iBeacon and Eddystone Enables organisations to customize the way visitors discover, connect and share what's around them through the use of indoor wayfinding technology. Microsoft Hololens Overlays digital visualisations on physical objects through a headset.

4.1.4 FREIGHT, WASTE AND CONSTRUCTION TRANSPORT

The movement of freight, waste and construction material in Old Oak and Park Royal will have different requirements and impact throughout the long-term construction period and the following operational phase.

When considered spatially, the freight and waste movement needs of Old Oak will be different from the needs of industrial Park Royal. To help supplement other studies, including the Park Royal Transport Strategy and Construction & Logistics Strategy, this section sets out a number of elements in relation to existing and emerging smart city concepts. Table 3 highlights the key elements, challenges, opportunities and use cases for freight and construction transport and movement of associated waste.

TABLE 3. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR FREIGHT, WASTE AND CONSTRUCTION TRANSPORT

Key elements	Key opportunities	Key challenges	Use cases
Integrated transport and freight network	Plan for rail freight from the start & distributing network capacity Consider using integrated logistics planning platforms to identify 'spare' passenger rail capacity for light freight movement to minimise traffic congestion, plus a consolidation area before moving it into the wider city.	Demand driven logistics Consider influencing the timing of freight movement and deliveries plus how to balance this with negative impacts (e.g. noise). Future proof urban drone delivery systems Understand the potential of using drones for last-mile delivery in urban areas, noise impacts, number of drones to utilize, regulatory challenges and the threats to privacy and security. Proximity to Heathrow makes this particularly challenging.	Use case exploration is underway Cargo bikes Cargo bikes provide a cost-effective way to move goods in cities. - The Tamar Cargo Bike can be fitted with an electric assistant pack with batteries and carry between 100kg to 150kg. - Zero Emissions Network (Zen) initiative between London boroughs of Islington, Hackney and Tower Hamlets allows businesses to trail low emissions cargo bikes. Last-mile rail freight The LAMIO project tested multi-model freight services into London and other major cities, using trains to transport bulk goods and smaller low-emission road vehicles for last-mile deliveries. InterCity rail freight Provides integrated freight transport movement for varied sectors utilising rail capacity.

TABLE 3. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Integrated transport and freight network	**Smarter logistics & last-mile delivery** Consider delivering goods to a secure locker (e.g. in a building); have a collection point near businesses and residents; and use of autonomous vehicles, cargo bikes and drones. Use of interoperable scheduling and route optimisation software will help to minimise impacts on the street network. Ensuring that infrastructure is in place to support the delivery of goods for 'click & collect' services to coordinated pick-up points will help to deliver space efficiencies across the development. Last-mile delivery solutions, including cargo bikes, drones, small vehicles and AVs, can help to facilitate increasing need for on-demand logistics. As such development will need to accommodate their movement and storage. **Freight consolidation & sharing** Consider establishing a consolidation area for aggregating goods before shipping it to the final destination; and use technology to encourage collaboration and sharing (e.g. online platform) amongst logistics companies. **Localised manufacturing** The potential growth of localised manufacturing and the aspiration to enhance the capacity of Park Royal may decrease the overall need for freight transport within Old Oak and Park Royal.	**Lack of freight consolidation & sharing** A third of delivery lorries are often empty. Consider encouraging companies to share vehicles and also use to pick-up (e.g. boxes to be reused, perhaps also large packages for mailing). **Coordination services** Use of spare capacity may be restricted by regulatory requirements.	**Voyage Control** Are using real-time scheduled and optimisation software to improve the flow of deliveries and pick-ups from busy hubs, like London Olympia and Canary Wharf. Similar approach may be needed to minimise traffic congestion (and avoid disruption to businesses as well as public sector service providers) in the densely developed Oak Park. It could also lead to increased logistics efficiency for the businesses based on Park Royal industrial estate.

4.1.5 STATION DESIGN AND MANAGEMENT

The emerging Local Plan sets out information for supporting the delivery of Old Oak Common Station (with High Speed 2, Crossrail and Great Western Main Line interchanges) alongside two new London Overground Stations and improvements to existing London Underground Stations.

The HS2 London-Midlands Act received Royal Assent in February 2017. Although initial design work for the station has taken place, detailed design work will be carried out. The size of Old Oak Common Station will be comparable to Waterloo and given the potential for over 250,000 people to be interchanging at peak hours, the need to design and manage the station and its environs effectively is critical to the success of Old Oak. The station is due to open in 2026 and as such the design of the station is well placed to consider how emerging and potential future smart city technology and digital systems can help to optimise its operation and role.

OPDC is promoting a station design that will be relatively open with a smooth transition between the interior station space and open street space, and allowing people who are passing through the station to make use of spaces and range of uses in and around the station. The opportunities and challenges below would equally apply to the London Overground and Underground Stations. Table 4 highlights the key elements, challenges, opportunities and use cases for station management and design.

TABLE 4. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR STATION MANAGEMENT & DESIGN

Key elements	Key opportunities	Key challenges	Use cases
Platform access	Free flow (360) station Explore having contactless and card-free services to facilitate the removal of ticket gates to provide additional public space and alternative station design which integrates with the wider built environment. B-Secur ECG biometric authentication Emerging ECG or related technology could enable easy access and payment to use transport services.	Station design The removal of ticket gates could have significant impact on the design of stations and platforms which would need to be considered in early design and feasibility studies. Utilising alternative methods for managing issues around revenue loss and security will need to be considered.	Birmingham Curzon HS2 Station Masterplan The current masterplan sets out aspirations for 360 degree station access which could support the removal of ticket gates in the future.

TABLE 4. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Safety and security	Station security Use of technology (e.g. low definition video feeds, machine learning, biometrics, video analytics) could improve the safety of people, security of stations and for controlling crowds.	Station digital security With increased use of technology and availability of data, consideration of using approaches to manage the physical and digital security of the station will be required.	QinetiQ Security Systems Provide systems based on 3D scanning to help manage security and safety of spaces and places.
Model interchange and facilities	Integrate stations & other transport modes Support the integration of transport models through personalised navigation (as specified above) and implementation of emerging transport modes such as Autonomous Vehicles (AVs).		Heathrow POD Terminal 5 Group Rapid Transit This is an automated transit system which can provide shared space for 6 to 30 people per vehicle compared to Personal Rapid Transit which can ride 3 to 6 people. - It can be used as an intra-city transport or for making connections between other modes. - It can allow for controlled vehicle movement; requires smaller infrastructure; uses less land needed for operation than other vehicles; can be shared by multiple users; reduces negative environmental impact; and it's completely automated. Delft Central Station Bicycle Parking in the Netherlands This is a good example of how integration could occur between stations and other modes. Delft has a 24 hour bicycle parking facility (for up to 5,000 bikes including cargo bikes) directly inside its railway station, where you can view free bike spaces, train times, buy tickets, and walk directly into the station hall. Many such facilities also incorporate cycle maintenance and hire facilities which may, in turn, be operated by social enterprises.

4.2 UTILITIES INFRASTRUCTURE

4.2.1 OVERVIEW

The utilities infrastructure within Old Oak and Park Royal represents many of the largest opportunities for using digital technology as well as presenting many of the greatest challenges.

Research has explored wide ranging aspects of utility infrastructure, ranging from the social acceptability of smart demand management systems to digital connectivity and the regulatory challenges surrounding many of the innovations identified in the workshops.

This section highlights the perceived key challenges and opportunities for local planning for regenerating Old Oak and Park Royal in relation to utilities. It presents the findings on how technology and digital systems can help to:

1. Digital communications
   Address the lack of broadband connectivity in Old Oak and Park Royal.
2. Utilities' assets
   Identify utilities assets, pin-point their location, and their capacity, above and below ground in Old Oak and Park Royal.

4.2.2 IMPROVING DIGITAL COMMUNICATIONS

The Park Royal industrial estate is currently poorly served by internet providers, which limits economic activity and could prohibit the growth of technology related sectors.

Within Old Oak, it is imperative that the area has world-class digital connectivity to aid its operation and to support its envisaged role as a new commercial hub for west London. There are regulatory and market barriers to addressing current issues in Park Royal and delivering digital communications infrastructure which is integrated with other utilities within Old Oak. OPDC will be developing a Utilities Strategy, informed by its Utilities Panel to set out a way forward to address these barriers. This section sets out potential opportunities and challenges to inform this forthcoming piece of work. Table 5 highlights the key elements, challenges, opportunities and use cases for digital communication.

TABLE 5. CHALLENGES, OPPORTUNITIES AND USE CASES FOR DIGITAL COMMUNICATIONS

Key elements	Key opportunities	Key challenges	Use cases
Wired digital communications infrastructure	Fibre optics broadband Fibre optics are the preferred data transfer technology for fixed point access. Early installation of fibre infrastructure co-ordinated with other utilities would be preferable to provide the backbone of the network.	Fibre optics broadband Understanding the barriers to installing fibre optic network infrastructure, its security requirements, and how to encourage telcos to invest up front will contribute to securing a network of next generation wired broadband. Scalability of infrastructure and redundancy risk Designing digital infrastructure to accommodate future upgrades and keeping track of new solutions in a fast moving market and new technology installation can be a challenge which must be considered continuously from the pre-planning phase.	Fast Broadband Ultra-fast broadband is currently being rolled out across the UK.
Wireless digital communications	Supporting emerging technology 5G mobile standards, still being developed, may provide better coverage in residential, public and commercial areas, including indoors. The New Generation Mobile Network Alliance (NGMN) prefer a system that emphasises more efficient (therefore cost-effective) use of the wireless spectrum, that will support low-bandwidth requirements for Internet of Things systems. Point-to-point wireless broadband can deliver ultra fast speed without the need for a comprehensive fibre optics network. Satellite internet communications is also evolving rapidly with low-orbit constellations and Ka-band.	Recognising the limits of satellite broadband Satellite broadband removes the need for wired networks, but it can be expensive and supports relatively low bandwidth. However, it would be suitable for patching so-called 'not-spots' in less connected areas.	Ka-band Satellite Technology Avanti has delivered reliable, high speed communication in areas lacking broadband. Optimity Optimity provide wireless digital infrastructure at wired broadband speeds within London's City Fringe where wired networks cannot meet demand.

TABLE 5. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Wireless digital communications	Addressing current issues in Park Royal Utilising wireless technology could present a feasible and quick solution to addressing current issues with broadband provision in Park Royal. 5G Innovation Centre Early engagement with this centre at the University of Surrey through the OPDC Utilities Panel could help future-proof future digital communications networks in Old Oak and Park Royal.		
Integration with other utility networks	Integrating utilities services Coordinating installation of utilities infrastructure can save on long-term management costs.	Lack of integration of utilities services Utilities providers tend to plan, deliver and maintain networks independently of one another due to market and regulatory restrictions.	London Legacy Development Corporation Implementation of coordinated utilities networks.
Powering digital communications infrastructure	Energy harvesting Extensive digital communications infrastructure, including public Internet of Things devices, will place greater demands on the local energy network. Emerging technologies can help to harvest energy from non-traditional sources such as Pavegen and Freevolt.	Increased devices & networks means increased need for electricity An increasing number of devices, networks and mobile based apps will bring an increasing need for electricity. This needs to be taken into account.	Pavegen Pavegen manufactures flooring technology that converts kinetic energy from footsteps into electricity. - 51 tiles in Heathrow Terminal 3 powers LED lights in the corridor. Freevolt Freevolt is a recent innovation from UK firm Drayson Technologies that provides perpetual power for IoT devices by harvesting radio frequency (RF) energy from wireless networks such as 2G, 3G, 4G, WiFi and Digital TV.

4.2.3 MAPPING AND MANAGING UTILITIES INFRASTRUCTURE AND CAPACITY

London's utility infrastructure is not only highly congested but also varies significantly in its age and condition. Old Oak and Park Royal is no exception.

Perhaps more importantly, given the age of many assets, the as-built records are not at the level of accuracy necessary to determine the location, capacity and characteristics of buried utilities. The result is a significant risk to development when attempting to determine the available utility capacity and location of buried infrastructure. This is not only an issue for the OPDC area but a common challenge across London.

This section sets out potential opportunities and challenges to inform wider utilities workstreams. Table 6 highlights the key elements, challenges, opportunities and use cases for mapping and managing utilities assets.

TABLE 6. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR MAPPING AND MANAGING UTILITIES ASSETS

Key elements	Key opportunities	Key challenges	Use cases
Identifying and mapping utilities assets	Asset-based infrastructure models Mapping and understanding all aspects of utilities assets over and underground for planning, delivery and management will deliver efficiencies in the short and long-term. Potential methods for identifying and mapping include IoT sensor devices, cameras, ground penetrating radar, satellite scanning and imaging (e.g. LIDAR). A combination of these methods is likely to be required. Specific elements to be mapped includes exact location and depth of assets in the ground, dimensions, position, relationship to other assets and its operational status. Importantly, it is necessary to understand the context in which each asset was first selected and used in the network.	Limited utilities asset information Current data on assets is regularly limited and in different printed and digital formats. Specific gaps relate to location, dimensions, depth, closeness and relationship to other assets, and its operational status.	Buried asset detection technologies: - EZiDIG sensor have been used to detect buried assets during excavators by locating electromagnetic signals emitted by buried metallic services. - Visualising Integrated Information On Buried Assets to Reduce Streetworks (VISTA): it's a collaborative project creating a framework for data sharing of buried assets in the UK. They are using technologies to be able to visualise integrated information on buried assets. - Ground Penetrating Radar (GPR): uses high-frequency radio waves for detecting underground assets. Ground with high water content and clay soils can limit investigation.

TABLE 6. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Identifying and mapping utilities assets		Access to reliable utilities infrastructure data A major inhibitor for efficient, cost-effective management of infrastructure is the limited accessibility of reliable data on infrastructure assets. Although some data is publically available, they can be difficult to access and use. Generation of reliable and credible datasets, through a common data environment, is often a bigger barrier than technology.	Overground asset detection technologies: - 3D Laser Scanners have been used for taking indoor and outdoor measurements. - Faro Laser Scanner was used to capture asset data on London Bridge. Groundwise Provides a service to collate the buried utility information within a specified area. However, information provided by the utilities is predominantly hard copy with no guarantee of geo-spatial accuracy.
Managing and maintaining utilities assets	Technology to monitor & maintain assets Technologies like drones, IoT sensor devices, LIDAR, ground penetrating radar, GPS, GIS and tags (e.g. RFID, QR codes, near-field) can be used to monitor and manage assets and their condition in real-time. These benefits should lead to sizeable reductions in capital and operational costs. In placemaking terms it will help to minimise disruption to the public realm through unnecessary exploration of assets.	Digital security of utilities infrastructure Utilities assets are of vital importance to the economy and form a key part of the UK's critical national infrastructure. As such, it is essential to ensure the security of digital information related to such assets. Over reliance Over dependence on digital connectivity when monitoring utilities assets can be a problem, especially during incidents that affect power. As such backup systems should be explored. Over regulation Over prescription of standards and policies can prevent innovation and scalability.	Hydro One & Accenture, Toronto Accenture supported Hydro One to access and integrate historical asset data and information from multiple databases and business applications that were either inaccessible or not integrated into the utility's information technology and operations technology networks. This will enable the Hydro One to better anticipate its grid performance by accessing integrated asset information to help identify and plan for short- and long-term investment scenarios and deliver performance outcomes that mitigate power system and on-going investment risk.

TABLE 6. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Managing and maintaining utilities assets	**Integrated utility information management systems and/or collaborative platforms** Establishing an information and knowledge platform based on Building Information Modelling (version 2 and/or 3) to be shared by different types of providers will support efficient and coordinated management of utilities. It will also enable decision makers to respond quickly and make decisions based on common data. Additionally, it will enable providers to understand how users are utilising and responding to products. OPDC could create an active information and management system that brings together multiple stakeholders, giving them the ability to influence outcomes, understand the decision drivers of other parties, share lessons and look for synergy.		
Sharing utilities information and data	**Engage with utility companies** Engaging with different utility service providers will help to foster collaboration, encourage consolidation of services, access information on assets, and understand issues. The current regulatory and financial structures are not able to distribute costs and future benefits appropriately which makes the process of sharing even harder. A project at the scale of Old Oak and Park Royal is perhaps the ideal test-bed to bring together the 'right' stakeholders to tackle this issue of data. **Capture contextual information on assets** In addition to mapping quantitative data, capturing contextual asset information is important to understand better the role of assets. This may require interviews with different stakeholders and surveys as methods to capture detailed information about assets. **Learn from other industries & models** Considering other models for sharing data could help facilitate the process. For example, looking at how the financial industry manages credit risk data and examining the Common Information Model (CIM) for data sharing and curation methods. Consider standards that allow best practices for sharing data including the the Hypercat standard on interoperability.	**Unlocking asset information** Most information on assets is owned, controlled and managed by utilities companies. It is important to identify and address the barriers for utilities data sharing and creating 'smarter' business models supported by digital platforms. Specifically it will be important for providers and regulators to understand in advance the direct benefits and risks to their management models, and plan accordingly. **Lack of data sharing motivation & incentives** Need to consider providing incentives to contractors and utilities companies to participate in information, skills and knowledge sharing. **Moving away from silos** There is a need to move away from silos and to encourage different utilities and energy providers to collaborate, consolidation services, share information on assets and understand 'blockers' to begin to address the wide range of infrastructure delivery and management challenges.	**London Infrastructure Delivery Board** Members of the London Infrastructure Delivery Board are continuing to explore the sharing of information to support growth across London.

4.3 SMART SUSTAINABILITY

4.3.1 OVERVIEW

Urban regeneration and development projects present an excellent opportunity to reconsider and implement policies, processes and technologies that can contribute to climate change mitigation and adaptation and create sustainable environments.

In order to understand some of the major challenges and opportunities in this area, this section highlights the perceived key elements, challenges and opportunities for local planning for regenerating Old Oak and Park Royal in relation to supporting the creation of a smart sustainable environment. It presents the findings on how technology and digital systems can help to:

1. Sustainable buildings

   Plan, deliver and manage sustainable buildings.

2. Improve air quality

   Manage and improve air quality.

3. Circular economy and sustainable waste management

   Reduce and manage waste as part of the circular economy.

4. Green infrastructure and open space

   Build a green space that promotes biodiversity, urban agriculture, supports recreational activities and promotes well-being.

4.3.2 SUSTAINABLE BUILDINGS

Buildings and open space are a crucial part of the urban environment. According to a report by the UNEP, globally the buildings sector contributes to 30% of greenhouse gas emissions and consumes about 40% of all energy.

This is mostly due to the use of fossil fuels during operations and from the use of construction materials. The report clearly states that if greenhouse gas emission targets are to be met, emissions from the buildings sector needs to be addressed with greater 'seriousness'.

Energy conservation for UK development, as a building's scale carbon emissions response, has been the subject of increased scrutiny for the last two decades; from the 'Merton Rule' (the first local authority introduction of a renewables policy) to the government's ambition that all new buildings would be zero carbon from 2019. The industry has learned many lessons on this journey, including that not all low or zero carbon technologies perform as well in practice as they do on paper, that over prescription in policy can lead to suboptimal and unintended outcomes, and that developers ultimately are more comfortable with bricks and mortar solutions than those relying on complex systems or with ongoing maintenance burdens. Many of the ideas raised at the workshops relating to carbon emission reduction for buildings fall into the three layers of the well established energy hierarchy including reduce demand, supply efficiently and use of renewable technologies. Table 7 highlights the key elements, challenges, opportunities and use cases for sustainable buildings.

TABLE 7. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR SMART SUSTAINABLE BUILDINGS

Key elements	Key opportunities	Key challenges	Use cases
Energy efficiency	Passivhaus Exploring how recognised approaches such as passive house could be embedded within a high density environment would lower energy demands for heat. Information & education Consider using technology to demonstrate the value to people of minimising energy consumption and demand.	Passivhaus barriers The regulatory barriers to passive house needs to be explored. Overheating in buildings Delivering highly thermal efficient buildings whilst being able to manage internal gains and heat loss from decentralised energy systems is a major challenge. The application of smarter energy management can help to address many of these issues.	Wikihouse WikiHouse is an open source building system. Many designers, collaborating to make it simple for everyone to design, print and assemble well designed, low-energy homes, customised to their needs. The edge building, Amsterdam Located in Amsterdam, the building achieved a BREEAM NL New Construction certification of 'Outstanding'. By employing innovative smart technology, the 40,000 square metres (430,000 square foot) Grade A office building achieves extremely high space utilisation factors whilst delivering world class energy efficiency.
Decentralised energy and resilient supply	Local energy production and storage Supporting local energy production in building design through existing and emerging solar, hydrogen, clean biomass and ground source heat technologies will help to reduce carbon emissions. Embracing flexible energy demand Supporting the use of virtual power plants or responsive energy demand systems could result in lower space requirements for physical energy infrastructure in buildings.	Space challenges for on-site renewable technology There will be limits to the quantum of on-site generation that can be accommodated on this site owing to the high density proposed. Exploring next generation solar PV technology should be considered, including Building Integrated Photovoltaics (BIPV) which become part of the fabric of the building and transparent solar panels to overlay any surface. Energy storage & distribution Exploring how energy storage and localised distribution will need to be embedded in buildings will require early consideration in detailed design.	Polysolar Polysolar have integrated photovoltaics (PV) technology into the curtain wall and windows of a building in the Cambridge business park. Such BIPV approaches could be attractive to increase the PV generation potential for high-density developments where there is limited roof space relative to the number of dwellings or commercial units. Tesla powerwall Provides a compact energy storage unit that can assist in smoothing peak demand times and draw energy from the grid when rates are low. Ubiquitous energy In early phases of development, transparent solar panels have been developed which can be used on a variety of surfaces. Open energi Facilitates flexible energy demand and usage to deliver efficiencies. Level 2 and 3 Building information modelling. Use of digital technologies for efficient ways of designing, developing and maintaining assets.

TABLE 7. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Temporary structures	Sustainable temporary construction methods Using previously utilised materials will help to embed the circular economy in Old Oak and Park Royal. Where recycled materials aren't available, emerging technologies producing bio-materials could be utilised.		Ecovative Ecovative produces bio-materials moulded from mycelium fungi which is used for temporary construction purposes.

4.3.3 MANAGING AND IMPROVING AIR QUALITY

Historically air pollution problems in the UK were related to power generation, industrial activities and domestic fuel burning, but the major cause of poor air quality is now traffic emissions, particularly in London.

Diesel and petrol engines emit a range of combustion related pollutants including nitrogen oxides (NOx including NO2), particulate matter (as PM10, indicating particles 10µm or smaller, and even finer PM2.5) and volatile organic compounds (VOCs). Sunlight-driven reactions taking place in the atmosphere between NO2 and VOCs can lead to the formation of ground-level ozone (O3), which is known to exacerbate asthmatic conditions.

A study by the Environmental Research Group at King's College on 'Understanding the Health Impacts of Air Pollution in London' suggests the total mortality from particulate matter (PM2.5) was estimated to be 52,630 life-years lost, and 88,113 life-years lost due to long-term exposure to NO2 in 2010.

The estimated economic cost for the health impact ranged from £1.4 billion to £3.7 billion. Whilst less quantified, the health impacts of other pollutants such as VOCs, ozone and carbon monoxide are well documented and present a serious concern to human health in both urban and rural areas. Thus, poor air quality is a public health risk and the OPDC needs to consider intelligent approaches and technologies to mitigate, prevent and adapt to this risk. The OPDC is developing an Air Quality Study to inform the draft Local Plan. This section provides supplementary information for how smart city technology can inform this work. Table 8 highlights the key elements, challenges, opportunities and use cases for air quality.

TABLE 8. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR AIR QUALITY

Key elements	Key opportunities	Key challenges	Use cases
Monitoring air quality	Establish the baseline Using existing Internet of Things air quality sensors, calibrated against AQN base stations will help to produce high resolution baseline. Use real-time information Consider using sensors with multiple features and software platforms that show information in real-time to continually monitor air quality.	Poor air quality data & limitations with current air quality devices As air is not static, data cannot be either. Current air quality applications don't present accurate, up-to-date information. Cost of Internet of Things air quality technologies Cost of sensors for air quality can be expensive and there is a need to bring down costs. New technologies are emerging partly driven by citizen demand in countries like China to address this challenge.	Air Sensa It is creating a UK-wide network of urban air quality monitors, starting in Greater London, to monitor and visualise air quality right down to individual street level. AQ Mesh Is a wireless system for measuring outdoor air quality. OpenSensors They have been working with the Air Quality Egg product which is a small electronic sensing system that sends data to the cloud and presents information in an application. Indoor monitoring In addition to outdoor, there are technologies that can monitor indoor air pollution such as the TSI meters. These are important during construction and for long-term monitoring.
Minimize construction vehicle pollution	Movement modelling and zero/low emission vehicles Digital modelling can help to lower air pollution levels when considered against other environmental factors. Zero or low emission vehicles (such as electric or hydrogen fuelled) can actively lower pollutants.	Using zero/low emission vehicles for construction movement Currently transport technologies do not support zero/low emission vehicles for construction purposes.	To be explored through wider OPDC transport workstreams.

4.3.4. CIRCULAR ECONOMY AND SUSTAINABLE WASTE MANAGEMENT

Waste and waste management has been linked with the availability of resources, energy need for growth and changes in our environment.

Traditionally, waste management has been part of the linear economy where products, materials and components are produced and then disposed of at the landfills. Whilst regulatory, policy and financial measures such as recycling objectives and landfill tax has made some improvements, waste will continue to be an issue resulting from, for instance, population growth, urbanization and increased availability of devices. In the UK, the waste hierarchy is a guide and a legal requirement to sustainable waste management which prioritises waste prevention, followed by reuse of whole items or spare parts, recycling, other recovery like anaerobic digestion and finally disposal.

Whilst the linear economy approach has worked to some degree, it is nevertheless wasteful. An alternative emerging approach to waste reduction and management is the circular economy, in which, products, components and materials are kept at their highest utility and value at all times. The circular economy approach provides a great framework to ensure that products are designed and used at their maximum value across supply chains and then recovered and reformed into another good at the end of each service life (see OPDC Circular Economy and Sharing Economy Study). To ensure that Old Oak and Park Royal truly establishes a sustainable approach to reducing and managing waste, it will need to consider how the circular economy can be embedded into the area. Table 9 highlights the key elements, challenges, opportunities and use cases for creating a sustainable waste management system recommended by the participants.

TABLE 9. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR SUSTAINABLE WASTE MANAGEMENT

Key elements	Key opportunities	Key challenges	Use cases
Waste as a resource	Circular economy OPDC should aspire to apply the principles of circular economy to waste management. Biofuels Waste can be used to generate electricity that can be fed into the grid or used immediately. Facilities and space needs to be available to promote this. Food compost and anaerobic digestion Wasted food can be used for generate compost. Facilities and space needs to be available to promote this. E-waste Electronic parts can be reused to minimise e-waste. Facilities and space needs to be available to promote this.	Coordinating waste management Management plans should align with other boroughs to achieve efficient delivery of services Design of properties, facilities and spaces for waste Using waste as a resource needs to be thought through as part of the planning and design process of buildings and spaces.	Ellen Macarthur's theory on circular economy It suggests to optimize resource yield by keeping products, components and materials in use at their highest utility both at the technical and biological cycles continuously. Recycling and reusing e-waste Mobicycle enables people to recycle their electronics and electricals including the MobiBin, locations for e-waste recycling, educational videos, and how to repair.
Waste collection and management process	Embedded waste collection systems Allow waste to be collected and sorted into compartments directly from within homes and facilities. Automated waste collection Sensors and analytics can be used to inform agencies when to collect waste. Compression bins Consider having waste compactors for compressing waste esp. cardboards.	Commercial and industrial waste Park Royal is an industrial area. Associated waste especially industrial waste needs to be minimised. Improving corporate responsibility for waste management should be promoted. Current waste collection and management processes Understand how clean are the current waste collection and management processes. There will be cost and environmental benefits to recycle on site rather than moving waste to other locations.	Waste management system Envac is working on various types of waste collection methods including: the underground waste and vacuum management system and outdoor waste inlets. Projects have been implemented in residential and industrial areas, public realm and nursing homes. Smart waste information system Symvaro's Wasteopia - a web and mobile smart solution that connects citizens and waste utilities, allowing to indicate, manage and communicate waste collection.

TABLE 9. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Waste collection and management process (continued)	Distinguish recyclable materials Improve how people and systems can sort out waste into different types of recycling materials. Make recycling convenient for people e.g. barcodes.	Social & environmental impact Understand, plan and mitigate for the social and environmental impact (including noise, smell, air pollutants, toxic chemicals and metals) that is likely to occur from waste management in the area.	Surplus food redistribution Plan Zheroes is a social network that connects businesses and charities for redistributing unsold food. Bigbelly – City of London Trial of smart bins to inform waste collection through use of Internet of Things technology.
Waste reduction	Sharing economy & local goods trading Consider establishing facilities to encourage people to share and trade products. Packaging collections Technology can be used to inform companies when to collect packaging materials from customers so that they can be reused e.g. food delivery boxes. Local vs. large businesses Have additional space for markets and smaller food businesses alongside multinational groceries and merchandise retailers. The former depends mostly of local products rather than economies of scale and its associated packaging. Promoting the minimal use of plastics and cardboards There is a need to reduce plastic and cardboard use for packaging and shipping. All types of plastic collection and recycling is key too.	Social contribution Behavioral change is key to waste reduction. There is a lack of applications and campaigns that can help people to make informed decisions e.g. how much waste they generate daily. In addition, make waste reduction convenient. Industrial & commercial waste Industries and the commercial sector can generate enormous amount of waste, many of which are harmful to the health. There is a need to reuse and manage efficiently waste generated by the companies in Park Royal and throughout the UK.	Companies collecting packages Food delivery services that collect packaging materials back from their customers. Similar models can be established to encourage reuse of materials and reduce e-commence waste.

TABLE 9. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Construction waste and transport minimisation and management	**Minimising waste creation** Using integrated Building Information Models (BIM) and lean prefabrication construction methods will help to design out waste as far as possible by coordinating 'waste' construction material supply and demand between phases and development plots. Given the role of Park Royal as an industrial location, a prefabrication plant could be established for the construction period of Old Oak. Using data analytics to help make waste a resource could also help to minimise resource use and embed the circular economy. Specifically, a site-wide materials database could be used to support this. During operational phases the use of smart waste systems to include smart bins and localised envac systems can keep road based waste collection to a minimum. **Non-road based local waste collection** Use of sub-surface local waste collection systems, such as pneumatic waste collection can help to reduce stress on the road network. **Smart bins** During operational phases the use of public smart bins using near-field communications could help minimise traffic generated through waste.	**Waste collection** Road based waste collections need to be timed not to impact peak time traffic, and have a consolidated process where a few companies collect waste from an area rather than many. Non-road based collection systems need to be considered in the early phases of development. **Local waste collection** Different waste authorities have different waste collection requirements and processes, which will need to be aligned with commercial private services.	**Wembley City Envac system** Development within the Wembley City is in operation and will provide a waste collection network for other 4,200 new homes and commercial uses once completed. **Bigbelly – City of London** Trial of smart bins to inform waste collection through use of Internet of Things technology.

4.3.5. GREEN INFRASTRUCTURE AND OPEN SPACE

When green infrastructure approach to land-use is planned, managed and delivered effectively, it has the potential to deliver multiple benefits to society, the environment and the economy.

These can range from promoting healthy living, mitigating air quality, noise and flooding, enhancing biodiversity to encouraging recreational activities. Good connectivity between different assets can maximise the value gained from this system. It can ensure that land is used in a sustainable way, and adaptable and resilient to change. Green open spaces that are well-designed can encourage people to walk and cycle rather than using transport that contributes to CO2 emissions; incorporation of urban agriculture can increase production of local food; and integration of trees between buildings can provide shade and reduce energy costs from cooling facilities (see Green Infrastructure: an integrated approach to land use). Green infrastructure is thus a crucial element of the wider urban infrastructure that will need to be considered for the Old Oak and Park Royal development.

Old Oak and Park Royal currently has limited provision of green and open space. Furthermore, connection and access to the largest green space, Wormwood Scrubs, will be difficult due to the major railway and road corridors. To build a sustainable, effective green infrastructure will require protection of the current green spaces, generating new green spaces, integrating these spaces into the utilities, transport and other infrastructure, and getting different stakeholders to adapt a green infrastructure approach at the pre-planning stage of development. Table 10 highlights the key elements, challenges, opportunities and use cases for building a green infrastructure and open space recommended by the participants.

TABLE 10. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR GREEN INFRASTRUCTURE AND OPEN SPACE

Key elements	Key opportunities	Key challenges	Use cases
Open space and urban agriculture vision and roadmap	**Urban agriculture** This redevelopment provides an opportunity to integrate urban agriculture across the area in the public realm and buildings at a range of scales. **Community gardens and allotments** Establish community gardens and allotments which provides an opportunity to grow local food and encourages social engagement. This could also include urban bee keeping and city farms. **Use of resources** Consider the relationship between open green space, urban agriculture and resources so that it's sustainable e.g. water use, soil requirements. Some options include: rainwater harvesting; collecting compost from residential and commercial areas; piezoelectricity; and generating power from pedestrian movement.	**Green urban challenge** Thoroughly understand the purpose behind creating an open space. Plan how the space will be maintained throughout its lifecycle from pre-planning, management and maintenance with the use of sensors. Could the space accommodate facilities for social activities and thus what is required to establish and manage them.	**Queen Elizabeth Olympic Park** This park has established waterways, wetlands, gardens, meadows and fields. Playgrounds have been embedded in the design. The area supports a diversity of different plants and other species. It's a good example of how horticulture can be designed into cities. The LLDC is working with UCL CASA in using sensors to monitor how open spaces are used to inform ongoing management and design of spaces. **The Green Exchange** A University of Leed supported project that allows students and communities to grow food in a communal space. They have worked on sustainable garden projects, the roof greenhouse, and other green projects. **Policy Exchange** Consider reports from the Policy Exchange which explore ways of improving green spaces in the UK including: - Green Society: policies to improve the UK's green spaces. - Park Land: How open data can improve our urban green spaces.

TABLE 10. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Shared and flexible spaces	Shared space with multiple purpose Design the area to encourage the sharing of private spaces and to get communities to share the area for different purposes and to become responsible for maintaining the area. For instance, school play spaces and commercial areas can be shared or used for other purposes after office hours; allotments can be shared; and recreational activities can be build into larger areas. The space can also be used to encourage the sharing of skills and knowledge, and to innovate.	Large vs small spaces As this area will be densely developed, there will be limited space for very large new open spaces. Rather than having separate small green spaces for residential and commercial purposes, create large green spaces which can be shared and bring communities together. Utility of open space Make the open space useful rather than just attractive e.g. green space with embedded urban agriculture could be used to teach children about farming.	Streetbank Allows neighbors to share their things. Sharefrome Allows one to share things with others.

4.4 COMMERCIAL USES AND HEALTH INFRASTRUCTURE

4.4.1 OVERVIEW

Commercial uses (including retail and employment) and health infrastructure can give people a place and an opportunity to meet and create a sense of community.

Old Oak and Park Royal will need to be supported by provision of social and commercial infrastructure to support the current and growing needs of the people living, working and visiting there. The scale of development in this area provides an opportunity not only to safeguard and improve the current facilities, but also to create new ones using Internet of Things technologies to provide better and smarter services. Given the proposals for high density development, OPDC will need to ensure that buildings and spaces are designed, delivered and managed efficiently to make the most use of any facilities. Part of the challenge will be ensuring these facilities are sustainable over time with appropriate stakeholders on board and securing appropriate funds to support operations. Securing the delivery of this infrastructure is fundamental to transform the area into a 'smarter' city that is attractive to the people who reside and visit there.

This section highlights the perceived key elements, challenges, opportunities and uses cases for social and commercial infrastructure that is relevant for the local planning policy. It presents the findings of how technology and digital systems can inform the following specific elements to:

1. Employment
2. Retail uses and health facilities

4.4.2 EMPLOYMENT

Old Oak and Park Royal provides an opportunity to secure high levels of economic growth and development.

This location has a long history of economic innovation with Park Royal being a crucial area for industrial growth that supports the wider London and beyond. In addition to the development of the residential, commercial, industrial and recreational areas in Old Oak and Park Royal, the regeneration of the new HS2, Crossrail and the Great Western Main Line station will further benefit London by presenting opportunities for new jobs. It has been estimated that Old Oak and Park Royal combined with generate approximately 65,000 new jobs that will benefit the local area, west London and London as a whole.

In addition to the existing sectors, such as manufacturing, construction, utilities, vehicle repair and wholesale, other sectors may be established in this area. OPDC is considering how to support these economic sectors to ensure they are able to function, operate and grow successfully. At the very minimum, this includes delivering a variety of working spaces for small, medium and large organisations, establishing digital connectivity, creating training facilities, and understanding the needs of the different sectors that are likely to set base in Old Oak and Park Royal. Table 11 highlights the key elements, challenges, opportunities and use cases for employment discussed during the workshops.

TABLE 11. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR EMPLOYMENT

Key elements	Key opportunities	Key challenges	Use cases
Understand future employment trends to support different businesses, institutions and employees	Open workspaces Design work space typologies and management structures to support a range of start-up businesses including maker spaces and flexible office space. Centre of excellence for innovation, incubators Engage with universities like Imperial College, accelerators, incubators, catapults and other associations to understand how innovation may change future employment and typological requirements for this area. Digital connectivity Establish fast digital communication to support businesses and other organisations.	Understand employer's and employee's point of view. There will be a need to cater for a more mobile workforce e.g. people who can work anytime, anywhere and who are always looking for new opportunities. How this disrupts existing modelling will be a challenge.	Impact Hub A global network of flexible workspaces with an aspiration to foster creativity and joint working. Acme Studios A London-based charity which provides affordable studio space and for non-commercial fine artists. Blackhorse Workshop A flexible 'maker space' providing workshop facilities.
Convenient, flexible and affordable workplace / space	Easy access to open workspaces Individuals and businesses, especially the smaller ones, need quick and easy access to be able to rent workspaces. Easy access to storage space Businesses, especially smaller ones, could benefit from 'smart self storage' with simplified arrangement for storing belongings. There could be opportunities for co-sharing storage spaces. Public workplace With the aid connectivity, it is possible to create public spaces where people can work from.	Affordability for small businesses Building small businesses from the bottom up requires new models e.g. renting space by the desk, so finding flexible and affordable office space is a challenge.	Renting workspaces Appear Here makes renting spaces as easy as possible as booking a hotel - with listings, searches and the ability to turn business leases around in a day. Such agility would be greatly helped by simplified lease structures. Coworking spaces London Enterprise Panel Open Workspace Provider Group, a workspace provider network, through which incubators, accelerators and co-sharing spaces (ICAs) can inform emerging workspace policies, share learning, and engage with boroughs and developers. The Machines Room Located in East London is a place for the public and businesses to fabricate their ideas. Examples of this initiative can be applied to Old Oak and Park Royal from an architectural point of view.

4.4.3 RETAIL USES AND HEALTH FACILITIES

Retail uses and health facilities will be an important component of the OPDC area to support vibrancy and sense of place of an area.

The development of Old Oak and Park Royal provides an opportunity to design retail and health services in the built environment from the planning phase and to upgrade existing ones. OPDC will need to establish and integrate a range of smart services that can provide adequate health services and facilities to meet the needs of the people living and working here, as well as promote healthy living and well-being from the beginning. These can range from integrating health and social care, place-shaping to encourage healthier choices, to providing welfare, education and specialist services. The challenge will not pertain to establishing the collect facilities, but to designing, connecting and delivering services in ways that it improves efficiencies in the health system, lowers down costs and encourage people to be more 'health responsible'. Table 12 highlights the key elements, challenges, opportunities and use cases for retail and health facilities discussed during the workshops.

TABLE 12. KEY ELEMENTS, CHALLENGES, OPPORTUNITIES AND USE CASES FOR RETAIL AND HEALTH FACILITIES

Key elements	Key opportunities	Key challenges	Use cases
Retail uses			
Develop flexible and integrated retail space to provide a diversity of services	Diverse area / high streets Create a vision of a 'healthy' High Street with plenty of independent stores, a healthy diversity of food and no betting shops. Demonstrator shops Create spaces where products can be demonstrated, distribution centres to help retailers, places one can visit to collect parcel deliveries and services to be delivered at offices and at home. Markets A market area would be a great asset to support start up retail. This could be mobile during the construction phases.	Accommodate disruptive retail - There is a danger that the high street will be dominated by larger retail companies, which minimises opportunities for SMEs. - Transport hubs could be dominated by food retail, so there is a need to balance this with other services and emphasise social activities.	Southbank centre market A good example of a market development in a local London area providing a variety of options. Hong Kong station-based retail Hong Kong has train station platforms with e-commerce support and retail outlets with small footprints. Seoul's train stations Seoul in South Korea has good examples of how retails in integrated with the public realm providing options.

TABLE 12. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Retail uses			
Design and build adaptable retail spaces for customers, businesses and institutions	Adaptable spaces The retail space could be build to have multiple functions e.g. a retail space for core hours and then the space could be used for something else. Fit for purpose retail / showcase Retail is likely to change drastically and space needs to accommodate for service types e.g. small areas for displaying selected products.	Address future retrofitting Commonly architects and designers create spaces that businesses has to be retrofitted in, there may be opportunities to design the space to adapt to future retail needs.	St Pancras International A good example of a design showing how retail services are easily connected with the main station, underground and the main roads. There are similar examples in South Korea.
Enhance digital connectivity for better retail services	Retail-based data and application services Digital connectivity can provide access to real-time data and lead to development of application services, providing information and new services to retailers and customers e.g. for travellers better information about local services including shopping, health-care, eating places etc.	Retail Connectivity Fast and reliable connectivity will be a key component of driving economic benefit for retail.	Geospatially aware applications Geospatially-aware smartphone apps (such as Shopkick) using beacon technology (such as Apple's iBeacon) that say what local retail opportunities are nearby, compared to what purchase you have made in the past.

TABLE 12. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Retail uses			
Future retail development	Click & collect services Spatial designs of retail needs to take into account development in click and collect services. Local production and demand-led Future retail space could change due to local food production and demand-led bespoke products. Sharing retail spaces With the sharing economy e.g. Airbnb, Uber, growing rapidly, there are similar opportunities for retail, many of them partnering or buying share-oriented start-ups. Using data to shape town centre boundaries With the growth of contactless technology and mobile device payments, payment providers can collect anonymised data which can be used to inform the location of town centre boundaries reflecting movement patterns.	Security and privacy for e-commerce Both security and privacy needs to be an integral part of the technical infrastructure for online retail. Affordable retail units As the retail sector evolves, the impact on spatial and size requirements needs to be considered by developers to ensure spaces are suitable and affordable.	Parcel collection network CollectPlus network of parcel drop off and collection points including news agents, supermarkets, petrol stations etc across the UK. Sharing economy retail shifts - Home Depot in the USA are renting rather than selling tools. - Walmart in the USA has developed an electronics trade-in program. - Pop Brixton in the UK is a new space created to allow start-ups and businesses to share space, ideas and skills. - Street Feast and Kerb provide market style locations and places for food trucks as affordable retail locations.

TABLE 12. (continued)

Key elements	Key opportunities	Key challenges	Use cases
Health uses			
New and multi-functional facilities	Multi-functional facilities with integrated services Health facilities could provide multiple functions and be integrated, for instance bringing together medical, social, dental, pharmacy, psychological, physiological and maternity services. Demographic mapping and forecasting Understand the demographical change to determine which services are likely to be most needed.	Supporting the population New health facilities will be needed to support the people living here and delivered in an effective and efficient manner. Monitor the vulnerable Facilities could have embedded smart technologies to monitor and help the elderly, disabled and other vulnerable populations at home.	Telecare: Dr Now and Babylon Health These smart phone apps enable you to contact private doctors on your smartphone and could be applied to an NHS model reducing the potential space demands for GP floorspace.
Smart preventive care	Supporting inclusivity Consider using technologies to improve the safety of the area to prevent accidents e.g. smart lighting to prevent falls during winter months. Support the use of sensors and geofencing to help manage location of vulnerable individuals. Use technology in the public realm and facilities to provide access to information about health services. Wearable technology Promote use of wearable technology that monitors general health. Further integration of health data with wearables can be used to prevent major emergencies early-on by detection.	Preventative care through interoperability Use technology to integrate communication between health services so that they can respond faster and address medical problems effectively. Consider having shared platforms of information to lower down costs and improve service delivery. Access to health data and information Access to health data by patients and many health service providers is limited. e-Health education Use smart technologies and approaches to provide educational health information to people so that they can make informed choices.	Wearable technologies, some examples include: - Healthpatch MD biosensor allows the monitoring of health vitals e.g. heart rate, respiratory rate, fall detection, single-led ECG and more. Develop Platforms for Sharing - Respect Network works on changing the digital world by restoring the trust in the Internet, security and privacy to allow sharing and communication of information. - Knowle West Media Centre engages with citizens to find smart ways to improve their health. - Patient Knows Best. Patients are in control of their medical records. EMIS Web Provides a range of services from online booking, accessing personal data, sharing information between health professionals and more. GP2GP Allows patient records to be transferred between GPs securely.

5.0 RECOMMENDATIONS

5.0 RECOMMENDATIONS

The OPDC should refer to the entire content of this report to understand both the perceived opportunities and challenges for the development of Old Oak and Park Royal. Below are the key recommendations drawn from the collected "crowdsourced" thinking from the participants in the workshops. The draft Local Plan should consider using the following:

5.1 TRANSPORT AND PUBLIC REALM

1. Dynamic street markings
   Explore the use of dynamic street marking to facilitate the shared use of public realm.
2. Smart city technologies
   Support the delivery of smart city technologies, including Internet of Things hardware that can provide up-to-date information to support sustainable transport modes and public realm management. Explore innovative localised energy sources for these.
3. Autonomous vehicles
   Understand the market development of autonomous vehicles and explore what impacts they will have on designing, delivering and managing the public realm to support their arrival.
4. Virtual modelling
   Use digital virtual modelling techniques such as by Space Syntax, and emerging methods, such as those using de-sensitised data from internet of things sensors, to inform the design of the urban environment to facilitate easy access and movement.
5. Digital and fixed signage
   Alongside fixed signage, support the use of digital signage, with interactive capability, to provide information to help people find their way and to make informed decisions.
6. Waste management
   Explore and support the delivery of waste collection systems which minimise impact on the public realm and use of space such as pneumatic waste collection systems and smart bins. Support the circular economy through the use of integrated building information models to design out waste by coordinating waste construction material supply and demand.
7. Last-mile delivery
   Support the delivery of spaces, infrastructure and methods (such as cargo bikes, autonomous vehicles and drones) to facilitate last-mile delivery services and localised manufacturing to meet demand.
8. Freight consolidation and sharing
   Support the delivery of a consolidation centre that can be shared by different service providers for aggregating goods before shipment to final destinations (for construction materials and delivering packages to people). Explore the potential for Park Royal to accommodate a construction pre-fabrication facility.
9. Free flow (360) station
   Explore and support the design of accessible stations that respond to new security and payment technologies.
10. Safety and security
    Use technology to improve the safety of people and security of stations.

5.2 UTILITIES INFRASTRUCTURE

1. Digital communication infrastructure
   Deliver world-class wired and wireless digital communications network that also addresses existing issues in Park Royal. Ensure technologies are future-proofed and able to accommodate change easily.
2. Innovation
   Work with emerging sectors and think-tanks to embed innovation in the planning, delivery and management of utilities infrastructure.
3. Energy harvesting
   Support the delivery of technologies that can provide low-carbon sources of electricity for low-power devices without the need for cables or batteries.
4. Detailed asset modelling
   Work with utilities stakeholders to capture detailed information about utilities assets to inform planning, managing and monitoring of the utilities network.
5. Sharing information
   Encourage utilities providers to collaborate, consolidate services and share information on assets to inform the planning, managing and monitoring of the utilities network.
6. Information and management digital platforms
   Establish integrated information and knowledge platforms that can be shared by different service providers to drive efficiencies in energy and utilities infrastructure planning and management.
7. Safety and security
   Support the use of technology that provides information in real-time to facilitate the security of utilities infrastructure.

5.3 SMART SUSTAINABILITY

1. Smarter building management
   Require the use of coordinated Building Information Management (version 2 and 3) across Old Oak and Park Royal.
2. Local energy production and storage
   Explore and utilise existing and emerging technologies to deliver local energy production approaches, responsive smart grid technologies and accommodate change in spatial requirements within the design of buildings and spaces.
3. Flexible energy demand
   Require energy utilities networks to facilitate flexible demand models to inform design and space requirements of infrastructure.
4. Sustainable temporary construction methods
   Explore and support the use of sustainable temporary construction material.
5. Monitor air quality
   Use Internet of Things technologies to measure baseline air quality and monitor the air quality in real-time.
6. Vehicle movement and air quality
   Support the use of low and zero emission vehicles to reduce air pollution.
7. Climate resilience
   Require development to the appreciation of resilience and a whole life value approach to decisions relating to overheating and green infrastructure.
8. Create clear targets and expectations related to energy strategies
   Set out a clear expectation with respect to strategies and targets, and provide an integrator role where outcomes are beyond the influence of individual development.
9. Circular economy and smart waste management.

   Set clear objectives to ensure products, components and materials are kept at their highest utility and value at all times rather than being disposed of. Work towards reducing waste generation and minimising the use of resources.

5.4 COMMERCIAL USES AND HEALTH INFRASTRUCTURE

1. Adaptable, flexible and affordable workspaces.

Ensure the design and development of work space typologies and management structures support individuals and businesses of all size.

2. Centre of excellence.

Engage with other innovation organisations such as universities, incubators and catapults to understand how innovation will require typological changes in the area.

3. Continuous skills development.

Create facilities and open areas that can support individuals to build continuously their skills and knowledge through engagement with communities, businesses and/or with access to specialised programs.

4. Flexible and integrated retail.

Encourage the provision of a mixture of services from SMEs and larger companies to provide a diversity of goods with flexible and shared space to demonstrate products or other use.

5. Market development.

Provide space for fixed and mobile markets which can support local businesses and local production of goods and services.

6. Security, safety and privacy.

Ensure that e-commerce does not compromise the privacy, safety and security of people and of organisations.

7. Integrated health facilities.

Establish facilities that brings together primary, secondary, mental, physical and social health care with improved communication between them.

8. Smart preventive care.

Use embedded technologies in facilities and the wider environment as well as encourage the use of wearable technologies to promote the 'preventive care' approach to health management.

9. E-education and health platforms.

Use technology to inform people about a healthier way of living and making healthier life choices, and encourage the development and use of secure platforms to easily access and share data.

10. Sharing economy.

Encourage the sharing of facilities, spaces and goods between individuals, communities and businesses.

5.5 CROSS CUTTING

1. Interoperability across data and systems

   Ensure interoperability across data and systems to enable innovation, drive efficiencies and lower costs across all services.

2. Scalability and flexibility
   Ensure the planning, delivery and management of Old Oak and Park Royal does not prevent scalability and flexibility in the infrastructure (e.g. technologies can be easily updated or removed at low cost).

3. Resilient and over dependence
   Ensure the infrastructure and public realm are able to withstand and recover quickly from incidents and failures and are not over dependent on connectivity in case of power outages.

4. Best-practice
   Make use of industry best practice in real-time monitoring and management of assets to drive efficiency and network performance.

5. Data privacy
   Though access to data is important for creating a 'smarter' approach for planning, delivering and managing Old Oak and Park Royal, privacy is important. An opt in and out model is needed for data sharing.

6. Incentive structures
   Create the right incentives to involve different stakeholders to collaborate and share information.

7. Lessons learnt
   Look at other industries and models (e.g. Credit Risks) where data sharing exists amongst different stakeholders, and understand where and why some smart city projects have and not have been successful.

8. Inform and educate people
   Use technologies and other methods to provide information to people and organisations in order to encourage them to make better and informed decisions, especially those that promote sustainability.

9. Safety and security
   Ensure safety and security is at the heart of planning, delivering and managing Old Oak and Park Royal.

APPENDIX

APPENDIX 1. EXPERTS FROM THE FOLLOWING ORGANISATIONS PARTICIPATED IN THE WORKSHOPS

99 Aha
Accenture
Advance Consultancy
AECOM
Aiseedo
Alcove
Amec Foster Wheeler Environment & Infrastructure UK
Amey
AquamatiX Ltd.
Area360
Asset Mapping
Astius Technology
Axillium Research
Baringa Partners LLP
Bikal
Birmingham City University
BIS
BOP Consulting
Brainn Wave Technologies Ltd.
BuroHappold Engineering
C4ST
Carillion plc
Carplus
Centre for Advanced Spatial Analysis
CGI
Cisco
City Region Research & Communications
City University London
Clearview Traffic Group
Core Three
Costain
Cushman & Wakefield
CyberCity 3D
Deberny Ltd
Deliver Change
Digital Catapult
Digitteria
eeGeo
Energy for London
EthosVO Ltd
EY
Flexeye
Future Cities Catapult
Goldsmiths
Greater London Authority
HOK
Honey
I&G Systems
IBI Group
Improbable
Innovate UK
Intel
Intelligent Networks
InterDigital Europe Ltd.
IoTUK (Digital Catapult)
Kemuri
King's College London
KPMG LLP
Laing O'Rourke
Leanpark
London Legacy Development Corporation
Lucid Environments
Maynard design Consultancy
McNicholas
MLM
MobiCycle
Morgan Hunt
Mott MacDonald
Neustar
NGO The Internet Foundation
OPDC
Open Data - Aha!
Open Energi
Open Geospatial Consortium
Open Reach BT
Opensensors
Ordnance Survey
PCSG
Peterborough City Council
Potentem
QinetiQ
RedBite
Resurgence
Retrofi
RTKL
Satellite Applications Catapult
Smart Energy GB
Smart Energy Networks Ltd
SOENECS Ltd
Space Syntax Limited
Stickyworld
Surrey County Council
Symantec
Sysdoc
TeskaLabs
Toshiba
Transport Catapult
Transport for London
Trusted Renewables Ltd
TTP
UK Power Networks
University of Brighton
University of Portsmouth
UrbanDNA
Vaquita/Neustar
Virtual Viewing Ltd
Vodafone
WSP/Parsons Brinckerhoff

* Note: This is not an exhaustive list. Several experts from other organisations preferred to be unlisted.

ABOUT OPDC

Launched on 1 April 2015, the OPDC's purpose is to use the once-in-a-lifetime opportunity of investment in HS2 and Crossrail to develop an exemplar community and new centre in north-west London, creating opportunities for local people and driving innovation and growth in London and the UK.

Website: https://www.london.gov.uk/priorities/planning/old-oak-park-royal

ABOUT HYPERCAT

Hypercat is a not for profit organisation driving secure and interoperable Internet of Things (IoT) for industry and cities. The Hypercat Consortium, co-funded by InnovateUK, is developing an IoT standard on interoperability and proving its capabilities through the innovation of technological solutions. Hypercat is Chaired by Lord Erroll and supported by organisations including Flexeye, BT, Cisco, KPMG, Symantec and WSP | Parsons Brinckerhoff.

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