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How digital technologies are shaping the city

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How digital technologies are shaping the city

NLA Insight Study

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Illustration drawn on an iPad by Julie Leonard

Contents

Introduction

It is calculated that 90 per cent of all the data in the world has been generated over the last two years. We are awash with data that can be grouped and utilised. Big chunks of this data are generated by the activities taking place in cities and can be used to make cities more efficient, greener, better places to live.

At one end of the spectrum, multi-national corporations compete to control the smart cities market which is forecast to be worth $400 billion globally by 2020, delivering systems to monitor infrastructure, energy, waste and transport. At the other end, an increasing amount of data can be gathered from peoples' handheld devices, from the new generation of watches or wristbands that monitor exercise and health.

The scale and exponential growth of the marketplace is increasingly complex. To get to grips with what smart technologies mean for the built environment in London, and those who work in it, this NLA Insight Study looks at systems that are available for designing and monitoring, at ideas for utilising data in the built environment and illustrates projects carried out by the industry to show how smart technologies are transforming the way professionals work.

NLA have collaborated with UCL's Centre for Advanced Spatial Analysis (CASA) as our research partners, who this year launch the UK's first postgraduate course in Smart Cities.

Peter Murray, Chairman, NLA

What is a 'smart city'?

Figure 1: Screenshot from the 'Future Life' film on display at the Crystal – a sustainable cities initiative by Siemens (online: http://www.youtube.com/watch?v=zuPlyqUcoA)

1

1.1 How do we define a 'smart city'?

By 2050, the world's population is estimated to increase from 7.2 billion to 9.6 billion[1], with 70 per cent of people living in cities.[2] As rising demand for resources competes with pressure to reduce environmental impacts, the host of complex tasks that cities have to deliver increasingly requires innovative solutions. London is not immune to such monumental global shifts. The population of the capital is projected to reach 11.3 million by 2050 and by 2031 London will need at least 641,000 additional jobs, 800,000 more homes and the infrastructure to accommodate 600,000 extra passengers on public transport at peak times.[3]

In recent years, the concept of 'smart cities' has emerged as an inventive approach to urban challenges with exciting potential. Based around improving a city's 'knowledge infrastructure', though data, technology and analytics, a 'smart city' offers the opportunity to better monitor, manage and respond to complex and sometimes competing demands, such transport, energy, environment and health.

Skiploads of documents and thousands of man-hours have been, and are being, taken writing about what makes a smart city. As the term gains increasing awareness, and expanding numbers of stakeholders look to the opportunities provided by a smarter approach, the UK Department for Business, Innovation and Skills (BIS) has commissioned the British Standards Institution (BSI) to develop a standards strategy for smart cities in the UK.

For the purposes of this study, we have roughly defined a smart city, and therefore a Smarter London, as one whose citizens, managers and suppliers come together to make intelligent use of technology and data about the way a city works, in order to improve efficiency and liveability and to reduce waste and carbon emissions. It is important to acknowledge that technology and data themselves cannot produce 'smart solutions', and that intelligent, common-sense human intervention is essential to ensure appropriate analysis, testing and response.

1.2 Is London a 'smart city'?

Over the last decade, London has seen a growth in the number of technology, science and research companies moving to central locations in the capital, with 'Tech City' in east London, King's Cross, Euston and White City attracting some of the leading specialist talent in the world, and offering London the opportunity to develop next generation data science infrastructure.

Major technology providers such as Siemens, Google and Intel, are also starting to make their presence known, many of which are partnering with London universities to explore the role of technology and data in the city. New centres

Figure 2: Screenshot from the Urban Observatory, an open access online tool that analyses the international performance of cities, online: http://urbanobservatory.org

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dedicated to smart city solutions include The Crystal in the Royal Docks, the Intel Collaborative Research Institute, and Future Cities Catapult – a research centre funded through £150 million from the Technology Strategy Board, while New York's Centre for Urban Science and Progress (CUSP) has also announced a possible London outpost at Canada Water in Southwark in 2018.

In December 2013, the Greater London Authority (GLA) released the first *Smart London Plan* to relate the smart city agenda to the issues faced by London, with the aim of 'using the creative power of new technologies to serve London and improve Londoners' lives'. The Plan sets out a number of key aims and measures of success, with the most relevant aspects for the purposes of this study identified as:

- To identify and prioritise which data are needed to address London's long term growth challenges;
- To make available the city's performance, consumption and environmental data as open data – including energy, water, waste and pollution;
- To showcase a 'robust 3D map of all London's underground assets, accessible and updatable in real-time by all asset owners and works planners' by 2020;[4]
- By 2020, to have reduced greenhouse gas emissions to 40 per cent below 1990 levels;
- To establish a Smart London Innovation Network by 2014;
- To increase the number of Londoners who think the use of digital technology has improved London as a city to live in.

1.3 The growing importance of data

'3D tools including sensing, mapping and monitoring are about to revolutionise the way we think, allowing for an unprecedented level of cross-correlation of data and analysis coming from different disciplines and fields of practice.'
Nicholas You, Independent Chair, UN-Habitat World Urban Campaign[5]

Now seen as the 'new infrastructure' for cities, many urban centres are beginning to collect, collate, analyse, disseminate and crucially, visualise a huge volume and variety of data.[6] After raw data is released, it can be transformed into striking visualisations which present the information in more intelligible and engaging formats.

Cross-correlation of data from different disciplines and fields of practice can quickly produce fresh insights to urban challenges, and encourage collaboration between fragmented groups such as citizens, academics, businesses and governing bodies.[7] From the development of a single building, to the use of water across the city as a whole, this allows immensely complex issues to be more quickly and easily seen and understood by an expanding group of stakeholders. For many industries, one of the biggest benefits of this approach is the ability to understand and explain issues at both a detailed level and within a global context.

Whilst digitised spatial information can be simulated to show predictive action and change, real-time visualisations and citizen feedback can be used to help understand operations within the city as events occur.

Governments are under increasing pressure to release 'big data' – or large complex datasets – as young start-ups and technologically savvy individuals create new platforms to analyse data and produce their own visualisations and apps. This has also been spurred on by publicity generated by initiatives such as the Guardian's 'Free Our Data' campaign and the Open Data Institute. The popularity of award-winning apps such as Citymapper, developed following the release of big data from Transport for London (TfL) and now estimated to be installed on 50 per cent of London's iPhones, demonstrates the value of open data and its potential to improve urban systems.[8]

A global movement towards the value of the SME economy and local production methods (including 3D printing) is also gathering force, with giants such as Ikea investing in local area research. The WikiHouse print and build concept is a good example of this (details in section 4).

1.4 How is data collected?

Data derived from the city comes from an endless array of sources, making its collation, analysis and application a formidable task. Much is collected by public bodies, through the Census; journeys on public transport; air pollution levels; energy and water usage; or education and healthcare records, while the private sector also collates vast amounts of data for their own applications.

Increasingly though, data can be derived from citizens themselves. Voluntary, though sporadic, contributions to apps such as Twitter and Mappiness produce fascinating insights into how people respond to specific locations, whilst GPS data from mobile phones can be used to produce real-time portraits of the movement of people through cities. The 'Real Time Rome' project directed by the MIT SENSEable City Lab involved tracking geo-specific data from mobile phones connected to Telecom Italia's network, along with data from buses and taxis. This data was transformed into striking real-time visualisations of the distribution of mobile phones and public transport, with benefits for urban planners seeking to maximise the practicality and quality of the built environment. An emerging way for citizens to collect data about their interactions with urban spaces is through wearable devices: with products such as the Samsung Galaxy Gear 2 and the Nike+ Fuelband already collecting and distributing real-time data about heart rate and activity levels.[9]

In-situ sensors – environmental, state and audio sensors – also permit detailed information to be captured about the performance of spaces. Future Cities Catapult is working with a series of partners to deliver a host of in-situ 'living laboratories' in London, where data will be collected, mashed and visualised, with the aim of producing innovative technological solutions, such as a 'virtual asthma-guard'. Sensors can also be used to improve the performance of a building at all stages of its life. Examples include Goldeneye, a scanner produced by Microtec to ensure that the laminated timber

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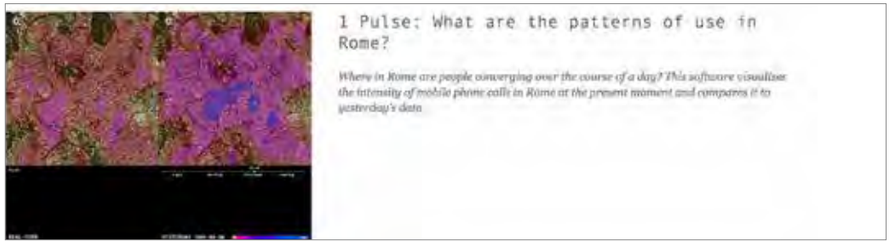

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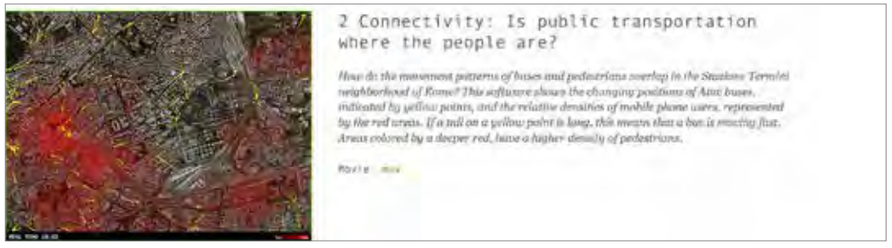

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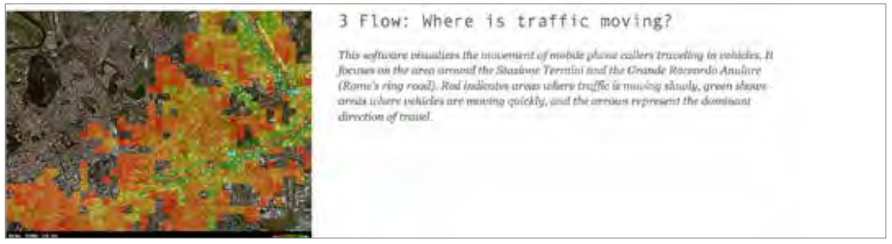

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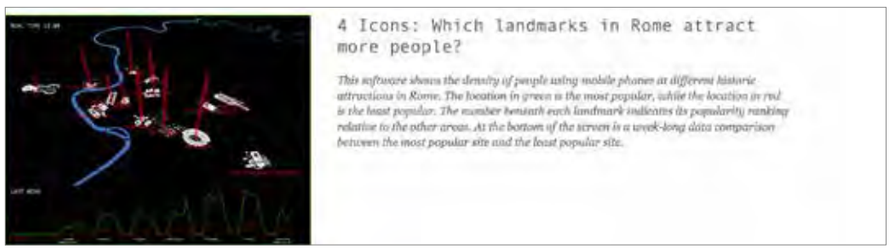

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Figures 3-8. Screenshots from the Real Time Rome Project coordinated by the MIT SENSEable City Lab, online: http://senseable.mit.edu/realtimerome/sketches/

components for the roof of the Canary Wharf Crossrail station are clear of imperfections[10] or occupation sensors at the Building Research Establishment's (BRE) Smart Home, which have delivered a 50 per cent reduction in carbon production.[11]

The Internet of Things (IoT) is defined as a system comprising of 'ubiquitous wireless sensor devices delivering real-time data on our world and our activities'.[12] Cisco estimates that by 2020, over 50 billion devices such as lampposts, parking bays and bins will be fitted with sensors and connected to the Internet.[13] Camden Town Unlimited (CTU) is participating in the international VITAL project to explore the potential value of the IoT for the local community. Although the project is at an early stage, CTU hopes to produce an open data repository where data about Camden collected from a variety of sensors can be accessed and aggregated to better understand urban processes.

1.5 What does all this mean for the built environment industry?

The enhancement of the physical environment through the intelligent use of technology and data represents one important facet of the smart city agenda.

London's built environment industry currently faces the challenge of modernising the city's energy, water and transport infrastructure to keep pace with the demand likely to be exerted by future generations. This gargantuan task demands a diversity of approaches, from data visualisations that inform citizens about urban processes and carbon-neutral technologies, to smart meters and targeted infrastructure projects such as Crossrail.

Data collection, analysis and visualisation are already transforming the planning sector to bring fresh insights to London's spaces. The intelligent use of digital technologies – such as CASA's work with biosensor headsets which analyse the emotions of blind citizens in London's busy streets – has the potential to help architects to better understand the city and plan for a positive and healthier environment. As community consultation schemes, such as Commonplace, are increasingly adopted to grant citizens the unique power to comment on the performance of the built environment, a new era of public accountability will arrive. The development of a Virtual London model from CASA, also poses a significant opportunity for the integration of information on future plans.

For the construction sector, the smart city agenda heightens the pressure to reduce the environmental impact of buildings, whether by using greener materials in new developments or retrofitting existing buildings. The uptake of Building Information Modelling or BIM is crucial to enhancing the ways the buildings are designed, constructed and inhabited, and helping the construction sector to meet increasingly stringent Government targets.

1.6 Which datasets does the built environment industry need?

For the built environment industry in London, the benefits of data release are yet to be fully realised and the RIBA has acknowledged that 'little has been done to explore the merits of using such data and new technology for planning and design processes'.[14]

Data collation and visualisations offer vast opportunities for a fragmented sector in which information about the built environment is often difficult, time-consuming and expensive to obtain. A vast amount of private datasets relating to the built environment are held by the corporate sector, with valuable data relating to the date of building stock, illegal dwellings, historical mapping and ownership documents held by businesses such as Geoinformation and the Land Registry.[15] For

example, if Ordnance Survey released its mapping data to the public, the 1:1250 scale maps that are intrinsic to the planning and building process could be used to powerful effect as accurate, up-to-date bases for the layering of data about the city. The integration of layers of data is a specific issue to be addressed, with architects and engineers owning vast amounts of data about individual buildings that could be of value to planners examining the way an entire area works.

On the other hand, over 9,000 datasets have been released by the government on www.data.gov.uk, while the GLA's London Datastore is a publicly available repository of raw data with a vast array of datasets, such as the Age of Commercial and Industrial Stock, Land Use Change for Dwellings and House Prices, relevant to stakeholders within the built environment industry.[16] The RIBA suggests that open data from local authorities could be harnessed to inform planning policies.[17]

Key visualisation sites are the Office for National Statistics, GLA's London Dashboard, the National Heritage List for England, the London Development Map, the London Heat Map, CASA's Mapping London, City Dashboard and Datashine.

Public accountability within the industry will be transformed by open data as the responses of citizens will increasingly need to be addressed.

1.7 Challenges posed by the smart city agenda

Although the concept of a smart city is in its infancy, it is apparent that it is complicated by some inherent paradoxes. For example, whilst global cities are under pressure to conserve energy in line with environmental targets, technological advances are encouraging energy consumption. Between 1972 and 2002, the electricity consumed by household domestic appliances in the UK doubled; between 2002 and 2009, the number of devices in British

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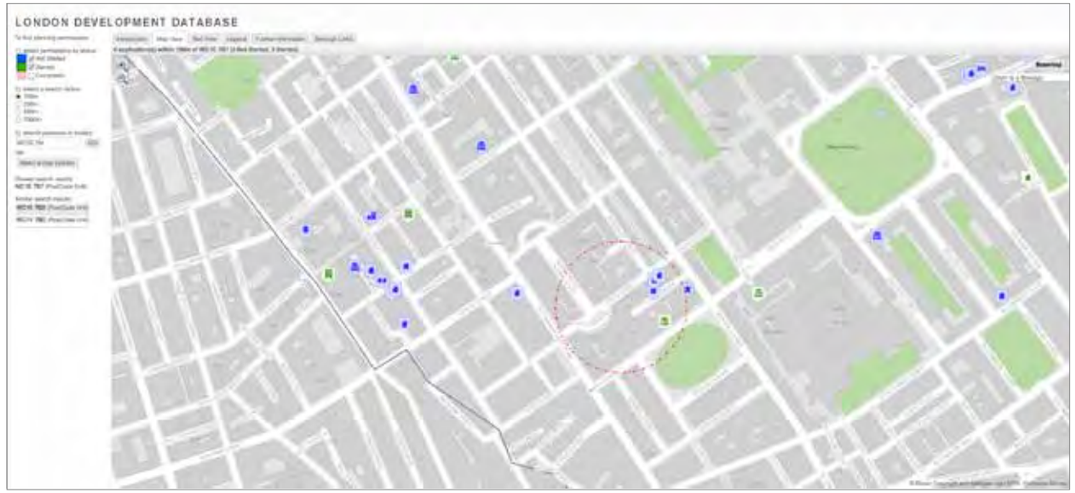
Figure 9. Screenshot of the London Dashboard, run by the GLA's London Datastore, online: http://data.london.gov.uk

Figure 10. Screenshot of CASA's City Dashboard, online: http://citydashboard.org/london



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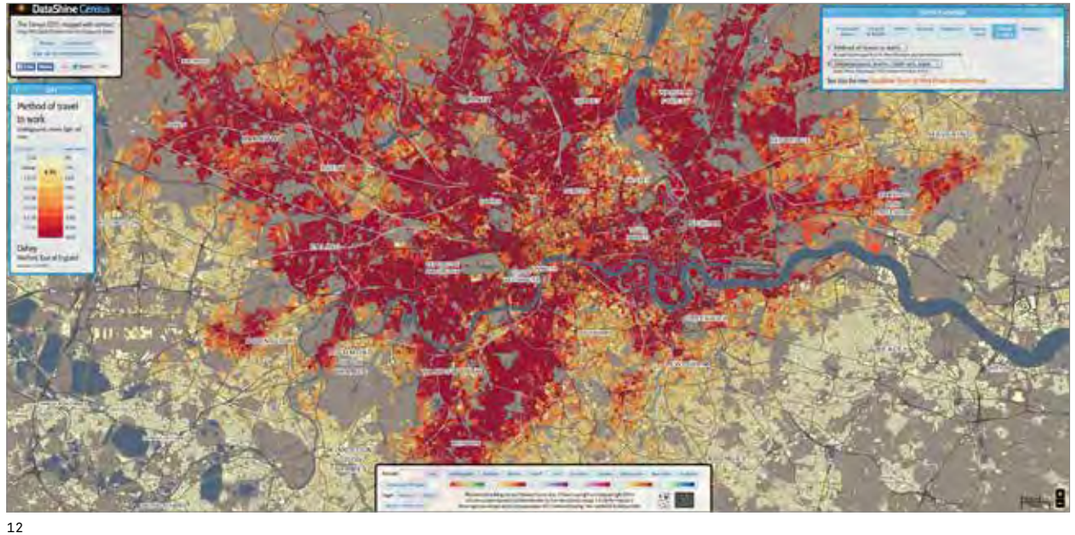

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Figure 11. Screenshot from the London Development Database, online: http://london.gov.uk/webmaps/ldd

Figure 12. Screenshot from Datashine, created by Ollie O'Brien and James Cheshire at CASA, online: http://datashine.org.uk

Figure 13. Social media use across Europe. Red dots are locations of Flickr pictures. Blue dots are locations of Twitter tweets. White dots are locations that have been posted to both. © Eric Fischer, online: https://www.flickr.com/photos/walkingsf/5912946760/in/set-72157627140310742

homes grew from 30 million to 65 million.[18] This complicates the approach to serious urban issues.

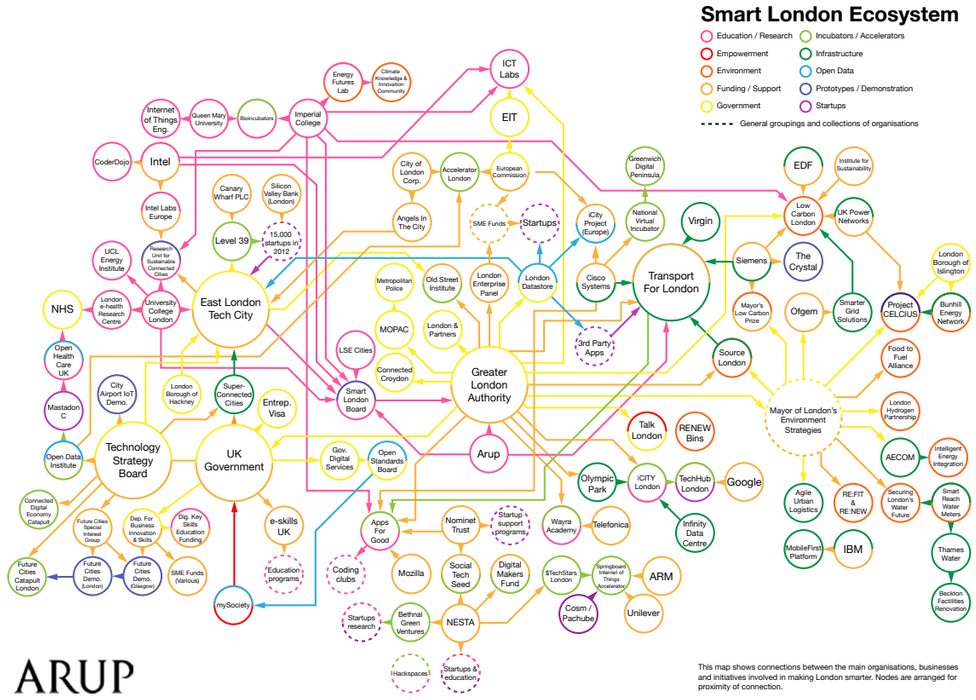
A vast 'smart solutions' market, estimated to be worth up to $400 billion globally by 2020, has rapidly emerged over the last few years. This has engendered a proliferation of information about smart cities, which, due to its volume and constantly shifting nature, can be difficult for stakeholders within the built environment industry to keep pace with and make sense of.[19] At the same time London, and other cities wishing to become smarter, must use common sense and not be buffeted by aggrandising promotional techniques. Smart technologies will only ever be of limited use if we do not identify and address real, longstanding problems.

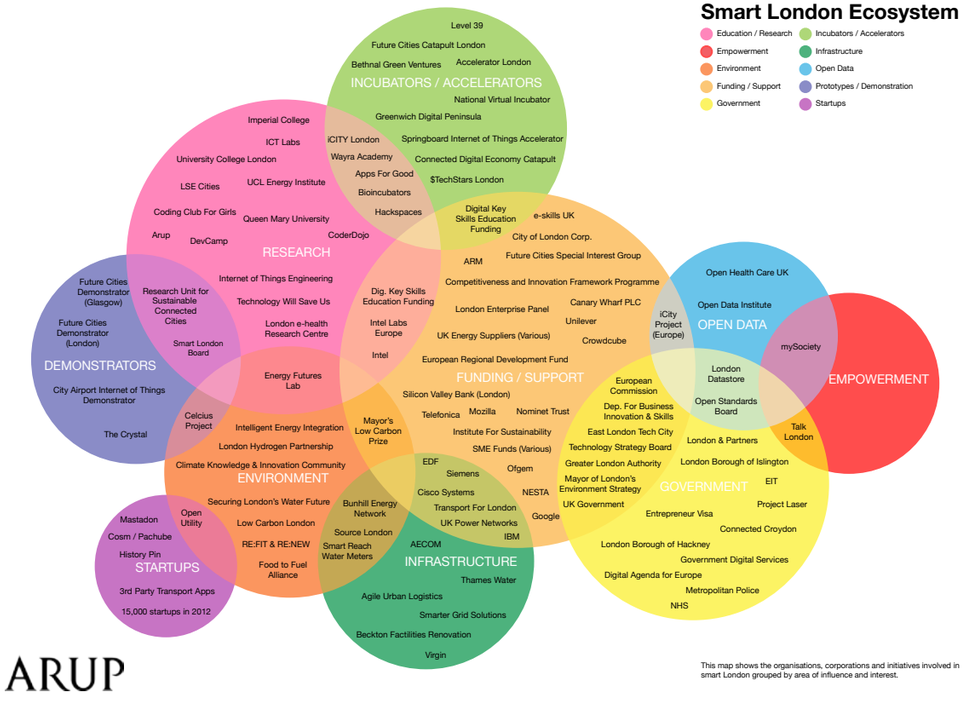
Another paradox is the need to release individual data whilst preserving a sense of privacy. There is a prevailing sense of uneasiness about the ways in which personal data is mined and sold: for the public to release data that is valuable to the built environment industry and serves the collective good, such as smart meter readings relating to energy consumption, this anxiety needs to be resolved.

Access to the Internet and high-speed broadband will also affect the realisation of the potential benefits of the smart city agenda for Londoners and the built environment industry. Currently, nine per cent of Londoners do not access the Internet on a frequent basis.[20] This is an element that the *Smart London Plan* also seeks to address.

It is crucial that the smart city agenda provides an intelligible framework for solving London's problems: one may find an analogy in the analysis of the Great Exhibition of 1851 by *Punch*, which noted that 'whoever can produce in London a glass of water fit to drink, will contribute the best and most universally useful article in this whole exhibition'. If the smart city agenda and its associated technological advances, like the Great Exhibition of 1851, addresses the most crucial issues for London, its citizens and the built environment industry, then its value, potential and benefits will be realised to exciting effect.

Figure 14. Smart London ecosystem map, courtesy of Arup and GLA





Planning

The collection, visualisation and analysis of data has the potential to transform the nature of the planning industry, bringing new efficiencies and fresh insights into the design of urban spaces. At the end of 2013, RIBA and Arup claimed that 'digitizing all information submitted for planning and making this data available to the public could unleash economic growth and help local authorities better inform their local planning strategies'.[21]

Aside from the potential benefits for the economy and local authorities, the application of smart approaches, technology and data to London's planning system is key to effectively addressing the unique challenges that the city faces in future decades, such as the projected acceleration in population growth and density. Smart approaches, including data visualisation, also offer the opportunity to ensure that London provides healthy, green and inspiring spaces that are tailored towards the needs of citizens. RIBA's discovery that 'the healthiest local authorities in our major cities have almost half the housing density and a fifth more green space than the least healthy ones' demonstrates that planning has an immense, and complex, impact on health.[22] What impact can smart technology have on the quality and viability of the city as a whole?

2.1 Masterplanning and Geographic Information Systems (GIS)

Geographic Information Systems or GIS describes a system that captures, stores and displays spatial or geographic information. GIS, and the intelligent application of digital technologies to planning, has the potential to transform the ability of planners to produce appealing urban spaces that effectively accommodate citizens. With many diverse projects currently underway, there is ample evidence that the collection and visualisation of data relating to London's urban environment can be harnessed to facilitate a vast range of planning improvements to benefit citizens in all their variety.

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Figures 1 and 2. Screenshots from Sky News video about CASA study. Top: the participant wears a headset fitted with electrodes that record electrical signals from the brain and provides data relating to his mental state. Bottom: When integrated with GIS data, this can provide accurate and objective information about how urban spaces evoke stress or positive feelings.[24]

One example is an exciting collaboration with the Future Cities Catapult, the Guide Dogs for the Blind Association and Microsoft in which CASA is using biosensing techniques to examine the impact of urban design on the emotions of blind and partially sighted citizens.[23] When integrated with GIS data, this provides accurate and objective information about how urban spaces evoke stress or positive feelings. In time, such geographic information could be used to influence planning decisions.

With its focus on using 'visual science', or a combination of psychology, attention analysis, optics and visual perception, to understand the built environment in greater depth, Hayes Davidson demonstrate the advantages of adopting a more scientific approach to cities in urban planning.[25] Hayes Davidson has engaged

Figure 3. The impact of the urban environment on human emotion, courtesy of CASA © Panos Mavros

Figure 4. Screenshot of a visualisation of London produced by Hayes Davidson (online: http://www.hayesdavidson.com/cityanalytics, accessed 18 August 2014)

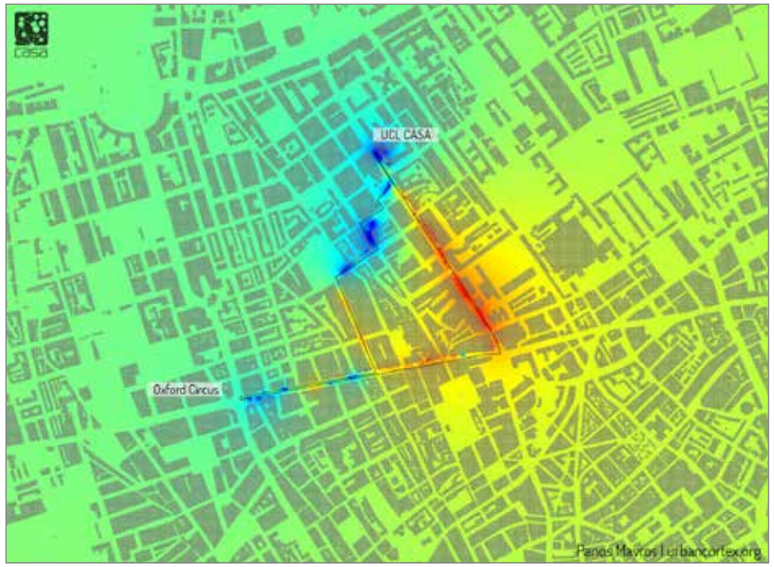

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Figure 5. Screenshot of images from Space Syntax's case study of the urban masterplan for Earls Court in London (online: http://www.spacesyntax.com/project/earls-court/, accessed 19 August 2014)

Figures 6 and 7. Screenshots of the Waterloo South Bank before (left) and after (right) the pedestrian modelling undertaken by Space Syntax (online: http://www.spacesyntax.com/project/waterloo-south-bank/, accessed 18 August 2014)

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with digital technology for years, releasing a visualisation of central London's protected viewing corridors in 2009 and today using advanced 3D modelling as tools to assist with tasks such as reaching agreement on planning decisions.[26]

The pioneering work of Space Syntax demonstrates the value of complex and dynamic digital urban models to masterplanning. Most recently, spatial modelling techniques and on-site surveys were used to advise on the Earls Court Regeneration Area masterplan. By rigorously analysing the local area using digitised spatial models, Space Syntax were able to identify the challenges and opportunities unique to the local area, such as transport links and the quality of the urban landscape, which then went on to inform the designs for the masterplan created by architects Farrells.[27] Space Syntax also benefitted from using pedestrian modelling to diagnose the problems with London's South Bank Centre; this enabled them to identify a circulation problem that was causing the disuse of certain spaces and advise on specific changes to the site to transform it into a positive, attractive and exciting space.[28]

The use of computerised pedestrian modelling by Crossrail and its consultants has also enabled in-depth analysis of the predicted movement of passengers before the line is complete.[29] With demand for Bond Street, Tottenham Court Road and Farringdon stations likely to be three times greater than at present, predictive pedestrian modelling by Arup, using Legion dynamic simulation software, has helped to influence planning decisions, from the provision of shops to traffic management and changes to policing,

Figure 8. Screenshot showing the projected entry and exit counts at Bond Street during the afternoon peak on a weekday in September. From: Arup, 'The Impact of Crossrail on Visitor Numbers in Central London', prepared for on behalf of the New West End Company, inmidtown, the Fitzrovia Partnership and Transport for London, working with Crossrail Ltd, Camden Council and the City of Westminster (January 2014), p. 35 (online: available to download at http://www.arup.com/news/2014_01_january/20_january_new_report_suggests_crossrail_to_handle_a_quarter_of_a_billion_visitors_by_2026.aspx, accessed on 18 August 2014)

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Figure 9. Screenshot of TransportBuzz, search term 'parks' (online: http://transportbuzz.com, accessed 19 August 2014)

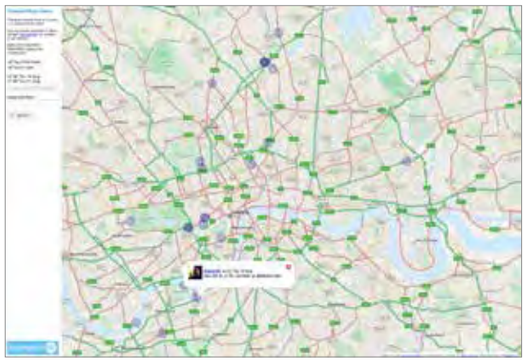

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Figure 10. Screenshot of the Commonplace Map of West Hampstead (online: https://westhampstead.commonplace.is, accessed 15 August 2014) © Commonplace Digital Ltd and West Hampstead Neighbourhood Development Forum

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so that they can be tailored more accurately to the pressures that the area is expected to face in future years.[30] Undertaking this work early on has also helped to influence the design of stations to support commuters and citizens in the long-term and identify future investment opportunities.

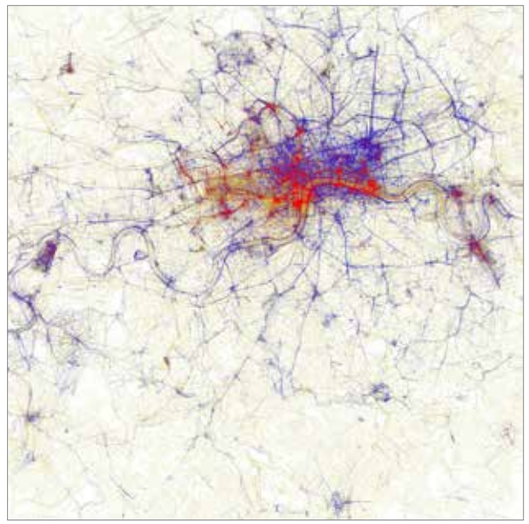
2.2 Community consultation and citizen feedback

Community consultation and citizen feedback are emerging as powerful tools in understanding the performance of urban spaces. By assessing the emotions that specific events and places evoke in citizens, it is possible for designers and planners to harness the urban environment to better meet their needs. There are many diverse projects currently underway that showcase the benefits of applying community consultation and citizen feedback to planning concerns.

Transport API, an open platform that helps to power transport operator sites, and transport apps, has recently produced TransportBuzz, a sentiment analysis map that displays geo-specific Tweets about the performance of London's public transport in real-time.[31] By mapping information about how Londoners interact with the city's public transport, TransportBuzz permits urban designers and planners to target problem areas and tailor solutions to addressing the concerns of citizens. Although it currently displays uncensored Tweets that sometimes have little relevance to planning concerns, it is an innovative platform with considerable potential to improve designs for urban spaces.

Commonplace operates on a similar principle, yet is targeted specifically at attracting local residents to comment on the performance of their neighbourhoods as an 'evidence base' to drive planning improvements.[32] Launched in February 2014 in collaboration with the Neighbourhood Development Forum, Commonplace West Hampstead has already attracted over 200 comments from residents about local planning issues.[33] There are a host of advantages to the implementation of local data analysis, from minimising consultation costs and reducing

Figure 11. Screenshot from the Geotaggers' World Atlas map of London created by David Fischer. The blue points on the map show where photographs were uploaded to Twitter and Picasa by locals, whereas the red points on the map show where photographs were uploaded by tourists (online: https://www.flickr.com/photos/walkingsf/sets/72157623971287575/, accessed 18 August 2014)



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the risk of expensive planning disasters to helping communities feel more connected to their surroundings.[34] These benefits can be felt by a variety of stakeholders in planning, such as property developers, councils and housing associations.

Citizen feedback techniques also involve less subjective and more passive forms of data collection and analysis that indicate how citizens interact with urban spaces. The Geotaggers' World Atlas, created by Eric Fischer, maps the specific locations where citizens have uploaded photographs to social media websites such as Flickr and Picasa.[35] It provides an objective way to evaluate the sights and views that citizens value most in cities. The growth in mapping citizen feedback offers planners the opportunity to ensure planning policies respond more readily to the wants and needs of Londoners – here, for example, the Geotaggers' World Atlas could be used to inform London's list of protected views.

Figure 12. Screenshot of the 'Streetscore' for New York. It uses an algorithm that assigns a score to a view of a street based on a prediction of how safe a human would consider it to look. The algorithm was created by Nikhil Naik during a collaboration between Macro Connections and the Camera Culture group at the MIT Media Lab.[12] (online: http://streetscore.media.mit.edu, accessed 18 August 2014)

12

2.3 Comparative datasets

The vast amount of data that is collected and visualised about planning in London is most useful when aggregated with other datasets. Visualisations such as the London Development Database created by the GLA – which provides a publicly available and up-to-date map of planning permissions in the capital – are convenient resources for analysing the city. Layering such maps with multiple datasets relating to transport, health and the environment can help to uncover the most exciting and meaningful conclusions.

Much work in layering information is carried out independently by academic researchers. Researchers at Queen Mary's, University of London and Imperial College have analysed half a million electronic patient records alongside Charles Booth's poverty maps of London during the 1890s. The research demonstrated that levels of deprivation in London's urban areas have not only remained similar over extended periods of time, but are intimately linked to the health of citizens. During the research for this study, CASA compared a house price map of London with an English Heritage map of the capital's designated heritage assets; the exercise provided instant evidence of the economic value of London's heritage. The diverse and fascinating data visualisations produced by Savills also present an opportunity to enrich and inform analysis of

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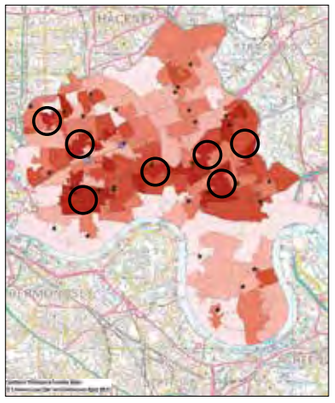
13

Classification of poverty

BLACK: Lowest class. Vicious, semi-criminal.
DARK BLUE: Very poor, casual. Chronic want.
LIGHT BLUE: Poor. 18s. to 21s. a week for a moderate family
PURPLE: Mixed. Some comfortable others poor
PINK: Fairly comfortable. Good ordinary earnings.
PURPLE: Mixed. Some comfortable others poor
PINK: Fairly comfortable. Good ordinary earnings.



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Percentage at high risk of diabetes

0.0-5.5
5.5-8.3
8.4-11.3
11.4-13.7
13.8-17.3

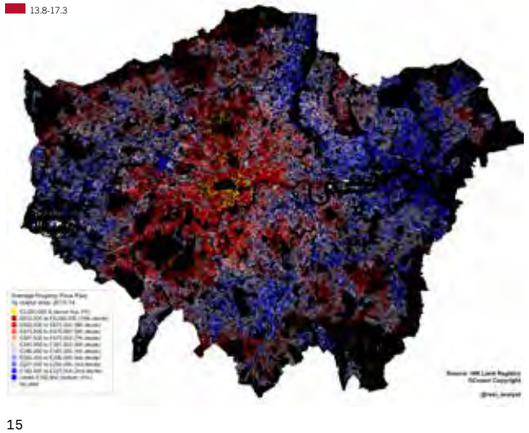

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Figure 13 and 14: Comparing the distribution of those at risk of Type 2 diabetes today with Charles Booth's poverty maps of the late 1890s.
13. © Library of the London School of Economics & Political Science, reference LSE/BOOTH/E/1. Adapted by Dr. Douglas Noble and Dr. Dianna Smith, Queen Mary University London.
14. Courtesy of Dr. Douglas Noble, Hon. Senior Lecturer, Queen Mary University London.

Figure 15: Average property price paid by output area, 2013-14 © Neal Hudson, Savills Research

London's built environment: the Savills house price map of London produced by Neal Hudson demonstrates that high property values cling to the edge of London's green spaces, including Hampstead Heath, Regents Park and Richmond Park. The use of comparative datasets can clearly assemble a much richer picture of London's fabric and communities, with powerful results for those seeking to improve the quality of its built environment. Collating and analysing data about London's fabric has the potential to assist in tackling significant urban issues such as health and poverty.

Exciting projects led by academics across the globe are also demonstrating the positive effects of collating and visualising data relating to the complex behaviour of cities. The 'Real Time Rome' project, directed by the MIT SENSEable City Lab for the 2006 Venice Biennale, for example, integrated geo-specific data about public transport and mobile phone usage to help reveal the 'pulse of the city' in real time, while the 'One Country Two Lungs' project, also directed by the MIT SENSEable City Lab, is currently layering data relating to pollution, spatial position, noise levels, heart rate and humidity to contrast the relationships between air pollution and health in Shenzhen and Hong-Kong.[37]

2.4 London's existing fabric

Since at least 80 per cent of the homes that Londoners will inhabit in 2050 already exist, smarter technologies are key also in helping us to understand the existing built environment.[39] An in-depth digital analysis of London's existing built fabric would be a powerful tool to enable the impact of new interventions to be understood by stakeholders.

The Netherland's Land Registry, Kadaster, has collected data relating to property since 1832 and today an interactive map of the country's 9,866,539 buildings – which visualises data

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Figures 16 and 17. Screenshots of video about the MIT SENSEable City Lab's project, 'One Country Two Lungs. The participant in the study traverses Hong-Kong and Shenzhen wearing a range of complex sensors that 'draws a dynamic map of Hong Kong and Shenzhen on the human scale, showing how we live in and move through urban space' (online: http://senseable.mit.edu/twolungs/, accessed 19 August 2014)

Figure 18. Screenshot of Illustreets, a website where one can search for the best places to live in England by comparing data on crime, house prices, schools and standard of living (online: http://illustreets.co.uk, accessed 19 August 2014)[38]

Figure 19. Screenshot of Amsterdam's built environment, showing the construction date of individual buildings (online: http://dev.citysdk.waag.org/buildings/, accessed 18 August 2014)

relating to the construction date of a property, its function and boundaries – is available to the public.[40]

London currently lacks a comparable resource relating to the built environment, where data relating to the existing fabric is collated, visualised and presented to the public. Although companies such as the GeoInformation Group sell data relating to the commercial and residential building stock, including the type, footprint and height of buildings, sources of open data relating to the built environment are fragmented.

A host of benefits would accompany the collation, maintenance and release of data about London's built fabric: the Kadaster processes approximately 100,000 exchanges of information every day to assist with areas as broad as policy-making, environmental and spatial planning, real estate and water management.[41] The broad interest

Figure 20. Screenshot of the London Evolution Animation, developed by CASA (online: https://www.youtube.com/watch?v=NB5Oz9b84jM, accessed 18 August 2014)

Figure 21. Image from Parson Brinckerhoff's Seattle model. From Emily Badger, 'Why 3D Modeling Will Play a Huge Role in Tackling Rapid Urbanisation', Atlantic CityLab, 18 January 2013 (online: http://www.citylab.com/tech/2013/01/why-3d-modeling-will-play-huge-role-tackling-rapid-urbanization/4439/, accessed 18 August 2014)

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of such information for the public at large can be demonstrated through the London Evolution Animation, developed by CASA, which used data from the Museum of London Archaeology (MOLA), the Centre for Smart Infrastructure and Construction, English Heritage and UCL to map and animate street development over history. In four months, the animation has received over 300,000 views via YouTube.

2.5 Virtual London

Stakeholders within the built environment industry are increasingly recognising the vast benefits of 3D city models to aid planning, development and construction. One of the most complete and extensive above and below ground 3D city models is Parsons Brinckerhoff's 3D Autodesk model of Seattle in the US. Originally produced as a visual aid to see new proposed developments in their wider context, it has since developed into a mega database of information about the city, and has proved useful to perform a variety of tasks, from visualising planning proposals and design alternatives to interrogating the impact of changes to urban spaces through predictive analysis and scenarios.[42] As datasets relating to factors as diverse as traffic, energy and water are aggregated with the city model, it has the ability to produce simulations to represent the exact consequences of planning and construction decisions in all their complexity.[43]

In London, Croydon Council, working with Arup, have also developed a digital planning tool that allows them to visualise all future planning applications for the area. As well as storing a significant amount of data on each project to aid internal communications; demonstrating the cumulative impact of multiple projects on an area at any given point in the future and thus offering the potential to mitigate any negative impacts; the model also offers the potential for residents of Croydon to visualise the impact proposed schemes on the area.

There is a growing awareness that smart technologies, such as 3D city models, need to be publicly available for their full range of benefits to be realised. Open data inspires creativity, generosity and collaboration: due to the public availability of data from OpenStreetMap, in August 2014 Harvard student Brandon Liu created CAD files of 241 cities across the globe and released them to the public as free AutoCAD and Rhinoceros downloads to assist with urban planning applications. Earlier this year, the Future Cities Catapult announced funding for an 'extended land use transportation model', which simulates the behaviour of citizens in London using open data relating to employment, population and transport, and 'the Virtual London model', a navigable 3D map of the city that will visualise outputs from the land use model along with environmental factors such as flooding and pollution.[45] With work on the models due to start in October, they present an exciting opportunity for Londoners and the built environment industry to benefit from open access to smart resources.

Figure 22: Screenshot of the Croydon Dashboard, showing the changing development site from 2015 - 2020. Blue indicates completed projects, red indicates projects on site, yellow indicates proposed schemes. Courtesy of Arup and LB Croydon

Figures 23 and 24. Left: A screenshot from OpenStreetMap showing buildings partially mapped, http://openstreetmap.org.
Right: A screenshot from Ordnance Survey's 1:1250 Mastermap, showing buildings accurately mapped.

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How can the industry encourage greater innovation in smart city projects?

By Nigel McKay
Innovation lead – Elephant Park at Lend Lease

What can be gained from developing or adopting a smart city strategy? Is it cost, time, functionality, amenity, health and wellbeing or something else? If you can answer the question, 'Why invest in smart cities?' with a positive set of responses, tailored for each different stakeholder group, then it would most certainly encourage more innovation and hopefully more funding.

What do people now, or in the future, demand from their interaction with technology? How will this demand be serviced and at what extra cost? A lot depends on drivers of course. For example, do you focus on residents, businesses, tourists, commuters, operators, sustainability groups, employment bodies or, in fact, all user groups? Each 'user' of a smart city may have slightly different needs, expectations, and gain different positive outcomes – if we can answer that in plain English, it will be difficult to hold the subject back.

As part of our plans for Elephant Park, we will deliver central London's largest new park for 70 years, and we are currently investigating how we can use new and evolving technologies to create a park that is able to respond to the needs and behaviours of all the different people who will use the park. This is already pushing us to develop and encourage our supply chain to be really innovative. It has also got us asking who are the right people to partner with and do they have solutions that we believe will help us in this space. We are therefore already hosting a number of 'innovation days' with our supply chain where we are able to explain to the senior managers of these companies what our key innovation and sustainability aspirations are for Elephant Park, which then provides a forum for them to explain how they can contribute to our plans most effectively. We are now in the process of setting our objectives over the next two, five and ten years so that we give ourselves the best ability to meet future needs, and deliver the smartest park possible at the Elephant.

Infrastructure

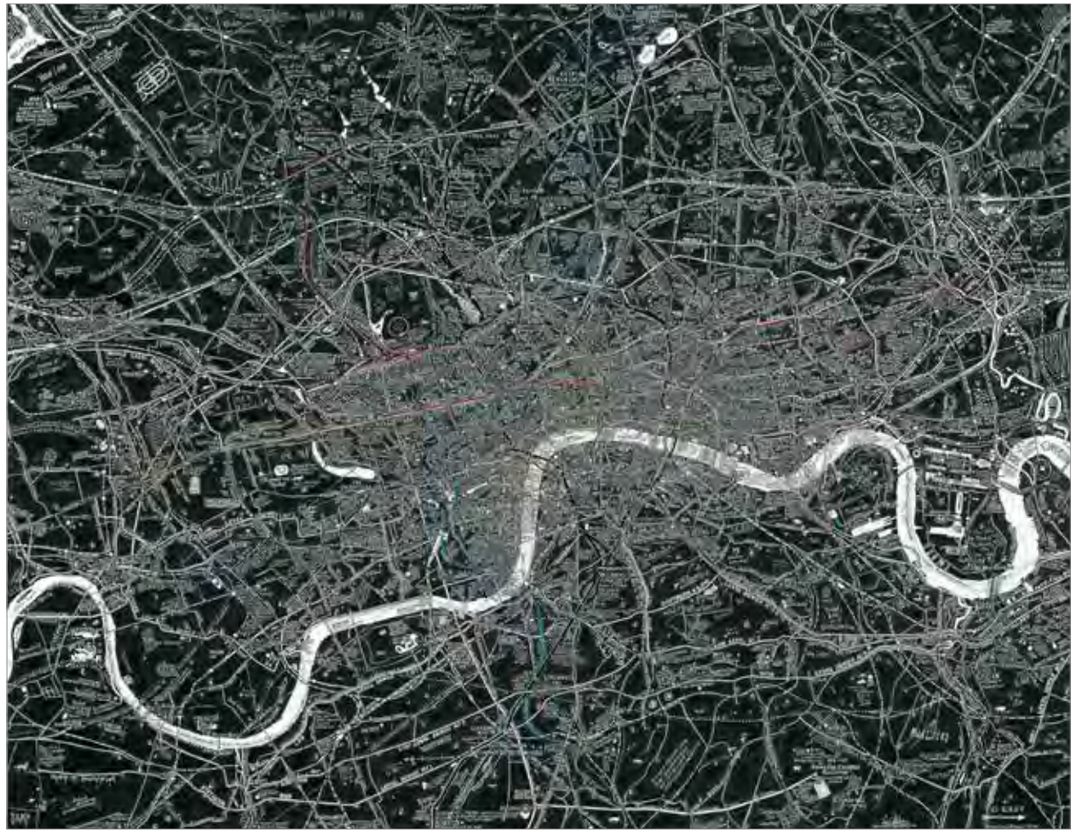

Figure 1. Stephen Walter - London Subterranea, 2012 (130 x 163 cm) Archival inkjet with silkscreen varnishes and gold acrylic. Edition of 50 - Published by TAG Fine Arts www.tagfinearts.com/stephen-walter/london-subterranea.html

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As London's population and density continues to increase, it is crucial for its infrastructure to keep pace with rising demand. Smart technology offers many solutions that could alleviate the unique challenges faced by London's energy, transport and water systems in the future. The benefits offered by smart technology are as varied as their exponents or pioneers, from major engineering firms and energy suppliers collaborating with local authorities to upgrade and 'futureproof' energy supply to the capital, to the substantial number of web developers producing apps meticulously designed to improve the experience of London's transport for citizens.

A promising feature of the *Smart London Plan* is its proposal to 'by 2020 showcase a robust 3D map of all London's underground assets, accessible and updatable in real-time by all asset owners and works planners'.[46] Although the development of an accessible subterranean map of London would be of considerable value to stakeholders within the built environment industry, it is also a formidable task due to the current lack of a central repository

for data relating to subterranean London. A vast amount of data is collected by about subsurface London by stakeholders such as Arup, TfL and Envirocheck, yet an artistic impression is the only detailed overview of London's underground assets that is currently accessible to the public (see figure 1).[47]

Although there are still considerable opportunities for the intelligent use of data and technology to address key problems for London's infrastructure, this is a rapidly moving sphere that has already witnessed a number of exciting and beneficial developments.

3.1 Creating a 'Smart Grid'

Population growth and technological innovations increasing both domestic and commercial energy consumption mean that demand for energy is growing rapidly, whilst supply is threatened by an increasing reliance on energy imports, the expense of storing electricity and the decommissioning of London's ageing power stations.

A key solution in the Mayor's *Smart London Plan* to the challenges posed to London's energy security is the creation of a 'Smart Grid', or the process of adding technology to the electricity system to increase the availability of real-time information about the network.[48] The key benefit of the movement towards a smarter electricity grid is the ability to use this information to make more intelligent decisions, whether this involves operators identifying problems earlier to re-route power, shifting demand to off-peak times to increase the reliability and efficiency of energy sources, or citizens reducing energy consumption to save money and reduce emissions.[49]

An important component in the development of a 'Smart Grid' is the use of decentralised sources of energy (DE). The Bunhill Energy Centre in Islington showcases the potential benefits of district heating schemes, as it already supplies cheaper, greener energy created from waste heat to over 700 homes. The network is currently being expanded and fuelled by the addition of new and reliable waste heat sources, notably from the London Underground.[50]

Other examples include Kingston Heights, a mixed use development of nearly 150 homes, a 140-room hotel and conference centre in south west London, Mitsubishi scientists have designed an innovative local DE project which draws latent heat from the Thames and concentrates it to produce domestic hot water at 45 degrees Celsius. Described by the Energy Secretary as 'game-changing', it is a carbon-free technology that will save approximately 500 tons of carbon emissions from being released into the atmosphere annually.[51]

Pavegen is another innovative DE project in which a sustainable source of electricity is harnessed from the kinetic energy produced by citizens' footsteps. In February 2013, Pavegen tiles were installed in Renaissance Works' offices in Bermondsey Street, providing enough power for employees and visitors to light their way to the main entrance of the offices, while also collecting footfall data.[52]

A Smart Grid also offers the opportunity to encourage behavioural change amongst energy consumers, through smart metering, which can provide more accurate real-time information on energy consumption and allow consumers to directly control and manage their energy use. The Government target is for smart meters to be installed in every home and small non-domestic property by 2020, which will involve replacing 53 million domestic meters.[53] UK Power Networks, London's distribution network operator, has been conducting a number of trials since 2011 under the Low Carbon London programme, to monitor energy use from more than 6,000 smart meters, while also testing electric vehicles, and undertaking active network management.

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Figure 2. Screenshot from Haringey Heat Loss Map, showing the heat loss data for Alexandra Palace and its neighbouring streets (online: http://www.parthiansystems.co.uk/haringey/, accessed 11 August 2014) © Parthian Systems (data supplied by Haringey Council, Bluesky and Ordnance Survey)

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Figure 3. Screenshot from Hotmapping website, demonstrating how the collection and analysis of thermal data can produce maps that identify 'problem properties' (online: http://www.hotmapping.co.uk/services/index.htm, accessed 11 August 2014)

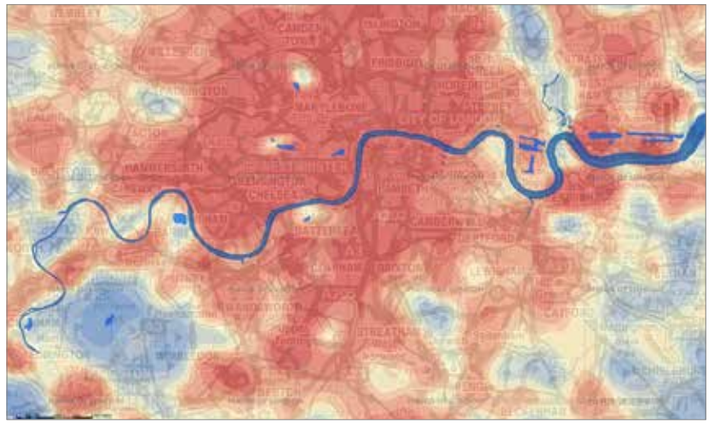

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Figure 4. Screenshot of the London Heat Map (online: http://www.londonheatmap.org.uk/Mapping/, accessed 12 August 2014)

As increasing amounts of data are collected about the movement of energy throughout the capital, it is possible to produce fascinating visualisations of London's energy consumption and thus better understand how it might be better managed. Heat-loss maps can be produced to identify energy inefficiencies, whether at the level of individual 'problem properties', such as the Haringey Council Heat Loss Map which mapped energy consumption at a building by building basis between 2000 and 2007, or at a local level, such as the London Heat Map, which uses heat mapping to identify the potential for decentralised energy projects.[54]

3.2 Managing London's transport system

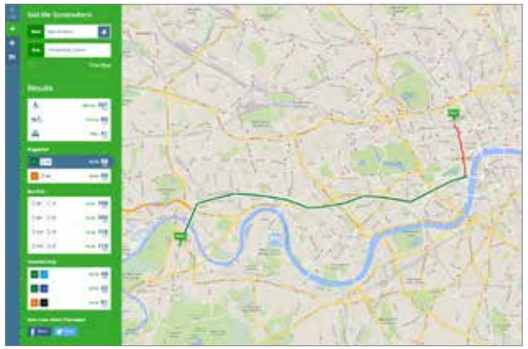
London's transport system is one of the most advanced and intelligent transport networks in the world. Approximately 80 per cent of public transport journeys in London are made using an Oyster card, permitting TfL to analyse a vast amount of data about how London's citizens and visitors travel in order to tailor improvements to demand.[55] Through its open data policy, TfL has released real-time data about London's transport network for use by developers in their own software and services, which has so far resulted in over 200 apps, from Citymapper to Tube Tracker, that aim to assist citizens with their daily

Figure 5. Screenshot of the online version of Citymapper (online: https://citymapper.com/london/superrouter?start=51.47703,-0.285252&saddr=Kew%20Gardens&end=51.519546,-0.132066&eaddr=The%20Building%20Centre, accessed 11 August 2014)

Figure 6. Screenshot of TfL's 'Find a Docking Station near you' map (online: http://www.tfl.gov.uk/modes/cycling/barclays-cycle-hire/find-a-docking-station, accessed 11 August 2014)

Figure 7. Screenshot of the Bike Share Map produced by Ollie O'Brien at CASA (online: http://bikes.oobrien.com/london/, accessed 11 August 2014)

Figure 8. Screenshot from Source London Charge Point Network Map (online: https://www.sourcelondon.net/map.php, accessed 11 August 2014)



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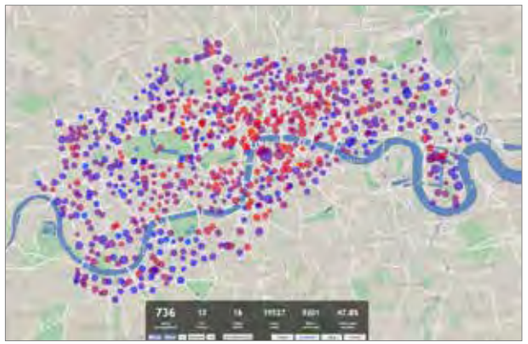

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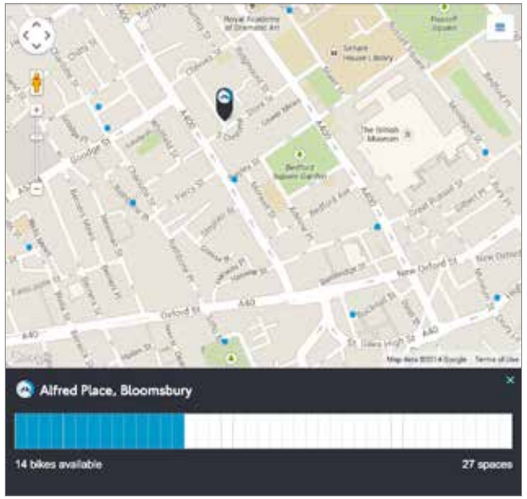

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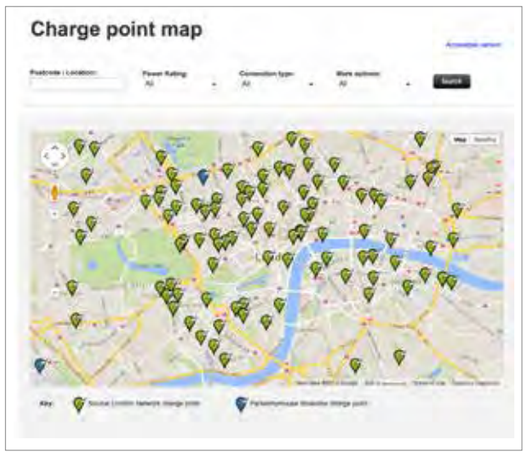

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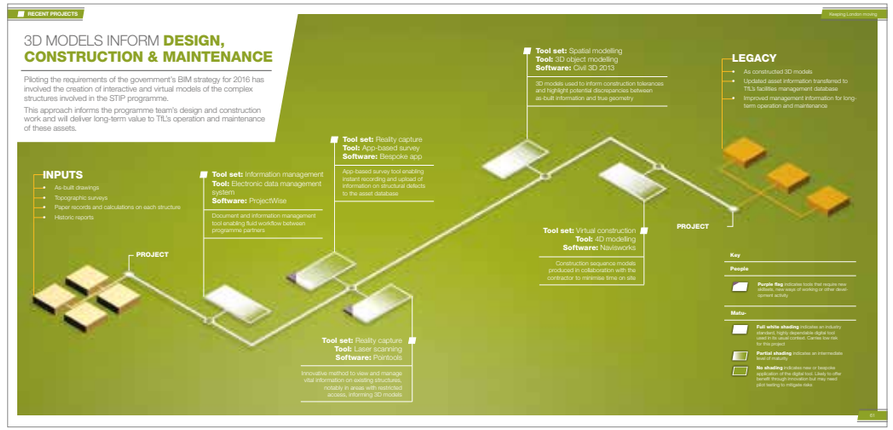
movements on public transport.[56] Cyclists using the Barclays Cycle Hire scheme can also use real-time animations that demonstrate the availability of bicycles at docking stations, such as TfL's visualisation and the Bike Share Map produced by Ollie O'Brien at CASA.

TfL are also exploring how to layer the various levels of data they collect to deliver more accurate real-time information on the use of the public transport network that takes into account the impact of factors such as weather, public events and engineering works.

The Mayor of London aims to introduce 100,000 electric vehicles to the streets of London,

Figure 9. Diagram demonstrating Parsons Brinckerhoff's digital approach to the TfL STIP programme, from start to finish (from Digital Life, Digital Legacy, p. 60-61)



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with access to the Source London network of public charge points.[57] Electric vehicles offer the opportunity to increase energy efficiency, through intelligent overnight charging that takes advantage of lower carbon energy.[58]

The development of driverless cars is another innovative technology that corresponds to smart city objectives. Google and car manufacturers such as Audi and Toyota have produced prototype autonomous cars and experts readily claim that 'by 2017-2018 the car will be able to drive itself, anywhere, any time without any human input'.[59] According to promoters they have the potential to reduce traffic accidents, commuter time, energy emissions and the number of cars by 90 per cent.[60] UK government is reviewing current road regulations to create a suitable environment for driverless cars and the Technology Strategy Board is offering £10 million to establish the UK as 'the global hub for the development and testing of driverless vehicles in real-world urban environments'.[61]

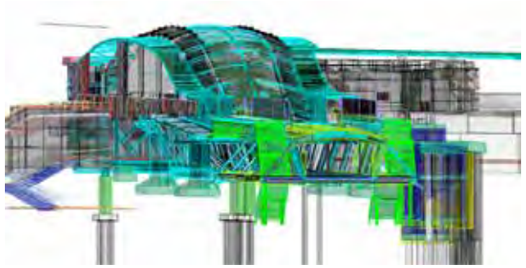
3.3 Delivering major transport projects

The efficiency of the construction and management of London's infrastructure is also being improved by the implementation of smart technology. One example is TfL's £300 million Structures and Tunnels Investment Portfolio (STIP) to strengthen and replace eight structures across London from 2013 to 2016 – including Hammersmith Flyover, the A406 Fore Street Tunnel and Chiswick Bridge – whilst keeping London moving. A digital strategy was applied to the entire process by consultants Parsons Brinckerhoff and Ramboll, with the aim of developing 3D BIM models for each structure that TfL could then continue to use for operation and maintenance. Data from each structure was collected using laser scanning to develop an accurate photographic visual representation of the ground conditions and structure. During planning and construction, this allowed the team to visually model the construction phasing in 3D and clearly map in the apparatus required while taking into account site constraints. It has also provided a sole location with information about the structures for use by all team members in construction and in legacy phase.[62]

Crossrail is also applying a number of smart technologies to its design and construction.[63] With tunnelling taking place underneath some of the

Figure 10. Image if 3D modelling used in the design of the Whitechapel Crossrail station (image courtesy of Crossrail)

Figure 11. Image of the underground modelling related to the Liverpool Street Crossrail project (image courtesy of Crossrail)



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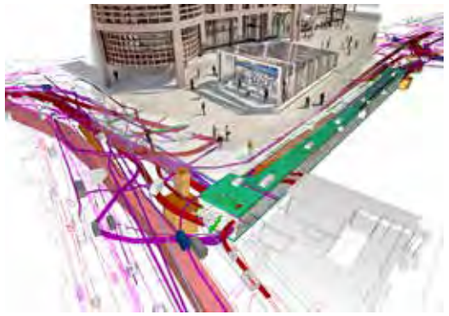

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most densely populated parts of the capital, and around complex existing underground tunnels and foundations, a host of in-situ sensors have been in operation to monitor underground and building movement as tunnelling takes place. Hundreds of low-cost sensors have been installed by University of Cambridge engineers in London's first 'smart tunnel' – an ex Royal Mail tunnel underneath Liverpool Street Station and just a few metres under excavations for the new Crossrail station – with the aim of monitoring and better understanding the impact of tunnelling on existing structures, and thus how London's Victorian and 20th century infrastructure might be better preserved in the future. Optical fibre has been installed along the length of the Crossrail tunnel to show if it is deforming or bending, while 'wireless displacement transducers' measure displacement of one part of the tunnel relative to the next. All of this will help to improve knowledge within the profession, and aid the development for future infrastructure projects.

Crossrail aims to be the first infrastructure project in the world to use Building Information Management (BIM) throughout its full lifecycle. Across all 25 design contracts for the project, Crossrail required each partner to work in a collaborative 3D environment, with all data integrated within a centralised information model held by Crossrail. So far the model incorporates

12

Figure 12. Screenshot of the Environment Agency's Live Flood Warning Map (online: http://apps.environment-agency.gov.uk/flood/142151.aspx, accessed 11 August 2014)

over a million individual CAD files, thus reducing information loss between contracts and project phases, and reducing project risk by giving greater visibility into design and construction processes. After construction, the 3D model can eventually be passed on to the operators and maintainers of the railway.[64]

Allies and Morrison, in collaboration with Arup, have also used advanced 3D modelling to inform the designs for King's Cross Underground Station.

3.4 Dealing with water and waste

At Thames Water, a single integrated geographical information system (GIS) provides a central repository of the whole geo-referenced network, including property assets and the subterranean property of other utilities. There are vast advantages to implementing a single, accurate and real-time model of Thames Water's assets that is available across all departments: one Thames Water expert noted that 'having the right data helps us in so many ways to improve the efficiency of our processes'.[65] The benefits of having a 'single view of the truth' include increased productivity, focused asset management, cost savings and quicker response time to problems.[66]

Data collection has also enabled the GLA's Drain London project to produce advanced flood risk modelling to inform citizens about the risk of flooding in specific locations through the Environment Agency's live flood warning map.[67]

How do you develop a digital strategy?

By Steve Denton
Engineering director at Parsons Brinckerhoff

With a multitude of digital tools available and fast evolving capabilities, how can we be confident that we are fulfilling the digital potential of every project? And how can we ensure that the right decisions are taken to make our projects 'smart'?

At the heart of these challenges is the way we select and combine digital tools. To be most successful, these processes require a clear vision and the disciplined development of a technology strategy. This strategy needs to promote collective understanding, reflect technology maturity and associated risk, and account for the impact of change on people. Crucially, the technology strategy also needs to recognise the differing – and sometimes competing – demands between scheme delivery and subsequent operational efficiency. At Parsons Brinckerhoff we describe these dual objectives as a productive 'digital life' and a valuable 'digital legacy', both of which need to be considered carefully.

With the cost of managing and operating an infrastructure asset typically dwarfing the cost of design and construction, the potential legacy value of digital assets envisioned and created during the early stages can be very considerable in comparison with their cost. However, when the way our built environment is created and operated is disjointed, the mechanism and justification for funding the necessary early investment is less clear cut.

The creation of smarter cities is set to play a crucial role in enhancing the efficiency of resource use. Harnessing this potential demands a whole-life view, articulated through a technology strategy.

Construction and building

Figure 1: Multi-screen BIM set up on-site, courtesy of Cullinan Studios (see page 46)

4.1 Building Information Modelling (BIM)

The building industry has long been complicated by the fact that the construction of buildings is a multi-disciplinary task with many different operators working on a single site. Due to the development of smart approaches, the opportunity exists for a more integrated, collaborative and scientific approach to construction.

Building Information Modelling (BIM), the process of generating and managing a digital representation of a building linked to a centralised database of project information, is a key smart technology for the built environment industry that is transforming the way that buildings are designed, constructed and inhabited. BIM enables the process of construction to become a more scientific practice in which the design, construction and habitation of a building relate to a reliable, collaborative and instantly updatable model. Since 2011, the adoption of BIM has increased by 41 per cent up to 54 per cent of professionals within the construction industry.[68] Although some have expressed concern about the clarity of BIM within the industry, the need for BIM training and the potential for small practices to be excluded, stakeholders are quickly recognising that it will continue to develop and influence processes within the construction industry.[69]

The uptake and influence of BIM is set to rise considerably – by 2016, collaborative 3D BIM will be a minimum requirement on all projects funded by the public sector, while the benefits for private sector led projects are also becoming more widely understood. Experts at Stanford University discovered that the implementation of BIM led to significant time saving, with a seven per cent reduction in project time and a 10 per cent time saving from the early detection and resolution of structural clashes.[70]

5D BIM technology has started to be implemented

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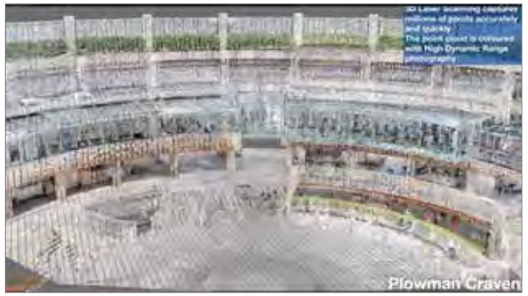
by practices such as John Robertson Architects, in which the fourth and fifth dimensions correspond to the cost and time to build, to provide a ‘full building lifecycle management, where design, construction and facilities management utilise the same, continually evolving, building model’.[71] A 5D BIM system consists of a 3D animation showing the construction process of a building, improved by the inclusion of a cost accumulator and timeline to show precisely the state of construction at any given point during the building process. One of the advantages of this advanced BIM software is the ability to prepare accurate cost schedules that can be quickly changed, along with flexible planning and control over the construction project. In-built clash detection capability saves a considerable amount of time checking the accuracy and alignment of details from different parties involved in the project.

BIM is changing the working environment for many architectural practices; smaller practices such as David Miller Architects have structured their office environments around a BIM workflow, with a strong focus on collaborative working: here, employees are positioned to face one another around a single desk with projects projected onto whiteboards to invite participation.

Figure 2. Screenshot from Plowman Craven's video relating to the Broadgate Arena development (online: https://www.youtube.com/watch?v=wlLcH1mTeLc, accessed 27 August 2014)

Figure 3. Section of Project OVE, courtesy of Arup

Figures 4 and 5. The BIM model for 240 Blackfriars Road, courtesy of BIM Technologies and GPE



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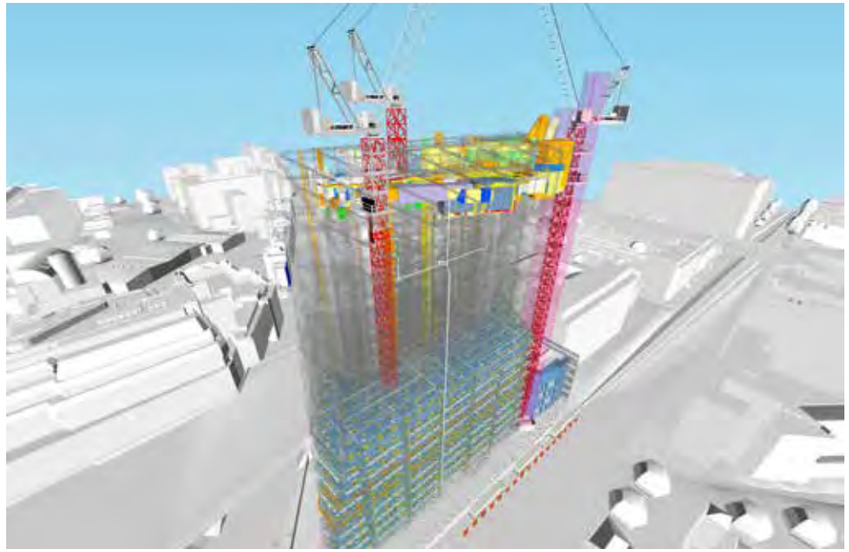
Over time, it is likely that 3D scanning will replace standard surveying models. The advantages of laser scanning have been demonstrated recently during a facelift at the Broadgate Arena in the City of London; Plowman Craven laser scanned every element of the Broadgate Arena using advanced scanning techniques to collect detailed and accurate data in 'point clouds'. This quickly created a detailed 3D digital representation of the Broadgate Arena, which, when combined with structural information and data relating to piping, cables and underground services to form a complete BIM model, could be used by British Land in future years.[72]

At 122 Leadenhall Street (otherwise known as The Leadenhall Building or the 'Cheesegrater'), prefabrication is proving to have significant advantages for a central London site with space restrictions and busy surroundings. It is the first time in the UK that advanced construction technology has been used to build such a tall commercial skyscraper. Installing pre-cast concrete floors, prefabricated floor slabs and steel columns enabled the construction process to be more efficient and produce less noise and waste – a considerable advantage for a complex building site in the heart of the Square Mile.[73] The team at Laing O'Rourke coordinated the assembly process with advanced digital technologies, including a BIM model and radio frequency identification (RFID) software, to allow building components to be tracked through manufacture, supply and installation. Integrating these technologies produced a 'data-rich replica of the project in real time'.[74]

Understanding of BIM has been enhanced through Arup's Project OVE – a digital representation of the human body in the form of a 170-metre tall building that features data-rich systems to represent the respiratory and circulatory systems.[75] The fire engineering group at Arup is studying the movement of smoke around the model and will install sprinkler systems to represent sweat, while Arup facade specialists will analyse how the 'skin' of the building performs in different weather conditions.[76] The model has pushed understanding of BIM to its extreme, with the team using BIM software and processes for as many applications as practically possible and only using processes that could be reused on projects in real-life situations.[77]

4.2 Post-occupation management

BIM remains a useful tool after the design and construction phase of a building's life, as it can be applied to the task of monitoring its performance and efficiency. Although post-occupation management using BIM allows for the behaviour of a building to be monitored in practice and adjusted accordingly, it is apparent that there is some distance to travel before the extensive possibilities of BIM for facilities management are realised.



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A growing number of stakeholders within the built environment industry are transferring BIM models created to aid the design and construction of a building to the client to improve facilities management over its lifetime. The BIM model created by architectural practice Hawkins\Brown for the Here East development at the former Olympic broadcasting centre will feature in its post-occupation management, while at 240 Blackfriars Road, Great Portland Estates (GPE) aims to use the BIM model as a full operational tool for facilities management. Furthermore, GPE estimate the cost of BIM implementation to only reach approximately 0.5 per cent of the construction value.[78]

Understanding the 'performance gap' between projected and actual energy performance is another area that can be improved through monitoring and data collection. A range of calculator tools, from the Energy Savings Trust online calculator and the Carbon Trust Empower carbon savings calculator allow citizens and businesses to clearly view how simple behavioural changes that reduce energy consumption can also lead to financial savings.

At Derwent London's White Collar Factory in Old Street, which aims to achieve both LEED Platinum and BREEAM Excellent accreditations, a considerable amount of thought has already

Figures 6 and 7. Screenshots from the Old Street Yard iPad app for monitoring the performance of the White Collar Factory in realtime, courtesy of Derwent London and Arup

6

7

been given to how smart technology can improve post-occupation management. Derwent London constructed a full-scale working prototype of the building to test energy consumption and its performance as an office environment.[79] When the White Collar Factory is completed, an iPad app providing real-time information on energy use and environmental conditions will enable users to interact with the building and adjust their behaviour. By encouraging its occupants to analyse real-time data on the performance of the White Collar Factory, the building is more likely to meet its target to reduce energy costs by as much as 25 per cent annually compared to traditional office developments.[81]

Figure 8. Screenshot of the Home Performance Labelling App, courtesy of HTA

8

Two large-scale Internet of Things (IoT) projects in London are at City Airport and Here East. At City Airport, an interconnected sensor network and data hub, funded by the Technology Strategy Board to create an IoT demonstrator project, will track, understand and better manage passenger behaviour and behaviour, bringing the ability to interact with passengers at key touch points across the airport. Key features will include management of passenger movement through the airport, journey time measurement, customer loyalty programmes and location specific programmes such as gate reminders, food pre-ordering and baggage tracking. The same approach is being taken by Hawkins\Brown at Here East – where flexible space is being created for technology start-ups – allowing a user to tailor their interaction with a building.

4.3 Enabling better consumer choice

The smart city concept may provide a valuable toolkit for addressing the issue of accommodating London's rising population in the context of its complex housing market. The growing recognition that the quality of new developments is as important as the quantity of housing they provide is fuelling the argument for home performance labelling. *Housing for the Information Age*, a report published by the Housing Forum in October 2013,

Figure 9. Proposed Royal Victoria Docks development by Carillion Igloo Genesis, courtesy of GLA

9

argues that home performance labelling should be applied universally on property advertisements to encourage and enable consumers to make more informed choices.

By providing detailed information on factors such as space and energy performance, data that is already collected for issuing EPC certificates, which could later be extended to include accessibility and water efficiency, home performance labels would give consumers the opportunity to compare quickly the costs of purchasing and running a home. With time, the government could introduce financial incentives for quality improvements to transform energy efficiency as a market differentiator and motivate housebuilders to deliver higher levels of quality and performance.[82]

Mind the Gap, which went live in April 2014, is the Housing Forum's home performance labelling pilot exercise which aims to show the benefits of informing consumers on the key aspects of a building's performance. The Housing Forum is appealing for its members to submit BIM designs for dwellings of any size, shape and tenure, which will be evaluated on various performance measures using BLP Butterfly software. The basic labelling will measure: floor space, storage space, energy efficiency, predicted energy costs, and daylight levels.[83]

4.4 Self-build and customisation

At present, custom build housing – the process of individuals or groups of individuals delivering housing for their own use, either building it themselves or working with builders – accounts for less than four per cent of the UK housing market. Yet in London, with a significant shortage of new housing being delivered relative to demand, if offers a potential model to increase delivery and improve consumer choice. The launch of the Right to Build programme this year, which created a £150 million fund to drive councils to offer as many as 10,000 plots to the custom build market, means it could rise in popularity.[84] The London Legacy Development Corporation (LLDC) are assessing demand for using the Olympic Park as an exemplar for custom build housing, while Carillion-Igloo-Genesis has plans to develop 15 acres of water at the Royal Victoria Docks into a floating village with 50 custom built homes.[85]

Digital manufacture offers an exciting prospect for the custom build movement, in which developers are able to offer a 'kit-of-parts' to buyers looking to customise their house. At Trevenson Park in Cornwall, 60 plots will be marketed to potential buyers who are able to use a 'PlotShop' to select their chosen house design and customise it with a choice of six manufacturers.[86]

The WikiHouse concept, by Alastair Parvin, also provides an open source kit to allow members of the public to design, download, print and assemble a house. It offers an efficient, cost-effective, creative and collaborative way to design and construct a house; an open source library encourages collaboration between designers and the method of assembling components arranged on large printed sheets allows individuals without specialist equipment or training to build a house using minimal resources.[87]

3D printing, in which successive layers of material are built up under computer control to

Figures 10-13. Foster + Partners, The Lunar Habitation, screenshots from http://www.fosterandpartners.com/projects/lunar-habitation/, accessed 26 August 2014

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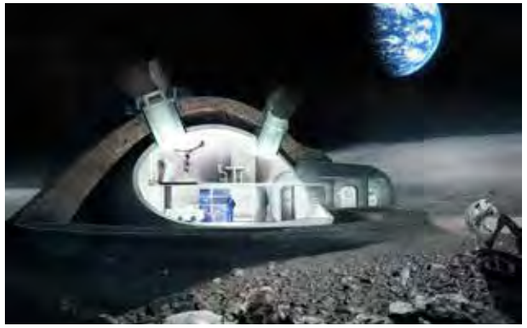

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create a three dimensional product, is another smart technology with potential to revolutionise the building process. Researchers from the University of California claim to have developed a 3D concrete printer that can build a house in a single day, based on a computer pattern. Such technologies offer the opportunity to reduce construction waste, speed up construction time and offer easier customisation of individual plots.

Foster + Partners, in collaboration with the European Space Agency, have taken this a step further through their exploration of 3D printed lunar homes, that would resist challenging extra-terrestrial conditions.[88] The Lunar Habitation would be constructed using an automated D-Shape printer to build up layers of lunar soil around an inflatable dome at a rate of 3.5m per hour, thus completing the entire structure within a week.[89]

How will innovations in building technology change the way we approach building design in the future?

By Mani Manivannan
Smart buildings consultant, Arup

Over recent years BIM has become a design tool for construction design that now has potential to add value to post-occupancy facilities management and maintenance processes by enabling an 'all-digital platform' for management of the built environment.

Next generation innovations in building technology will harvest data from a multitude of sensors using what is increasingly becoming known as Internet of Things (IoT). For example: sensing occupancy and presence; utilisation of assets; the uptime/downtime of vital equipment and services; safety monitoring of structures; capturing energy utilisation; and efficiency of power consumption at a granular level.

All these and more will create new 'big data' sets that will offer fresh insights and feed intelligence back into the design of future buildings.

We predict that innovations in building technology will be greatly influenced by information produced from the new science emerging from 'big data analytics'. BIM will evolve to become a more intelligent modelling tool for building designers offering real-time simulation studies of the physical world based on real data sets and what-if scenarios created out of the new science of building ergonomics. A further innovation could be a truly immersive design cave where architects and engineers could evaluate alternative designs using a fully animated version of a 3D BIM model. It is likely that those involved in creative media and immersive game play technologies will contribute to next generation BIM technologies.

How will technologies change the office of the future?

By Benjamin Lesser
Development manager at Derwent London

Technology has shaped how occupiers work and redefined what they need; we have to develop space that can meet their new requirements. Our creative tenants desire more personalised space to reflect their business culture and character, not conventional floorplates with inflexible services; they want to adapt and change their environment, and expand and contract as they need. People come first and productivity is key. Other businesses are now taking heed.

Technology is also has shaping the way we design workplaces. It enables our design teams to model their proposals in 2D and 3D, work out complex structures, test out new heating and cooling systems, communicate with consultants online; it enables us to build using innovative – sometimes recycled – materials, operate and manage buildings more efficiently and effectively with smart servicing systems. New infrastructure – transport and wireless connectivity – has enabled us to build in new areas. We can create and refine at the touch of a button and can beam proposals to potential tenants across the world. At White Collar Factory, we have re-thought many of the office norms in response to the views of our tenants. This has enabled us to simplify the building and focus on spatial qualities and better principles to provide light, height and flexibility – a longer-life, looser-fit approach. Comfort is achieved by tall ceilings, allowing heat to rise, to be taken away by concrete core cooling with pumped cold water in the slab. The facade is composed of glass, solid panels and perforated metal panels to minimise overheating and enable windows to be opened for fresh air. More natural light is let in due to the 3.5m ceiling heights. Altogether, we are achieving more with less and around 25 per cent in energy running costs can be achieved.

New technologies have shaped White Collar Factory and White Collar Factory gives occupiers the freedom to shape the way they work – it's future proof.

Recommendations

Perhaps one of the smartest interventions in urban planning occurred in 1854 when the physician John Snow, through mapping movement of people, found that nearly all the deaths in the Soho cholera epidemic had taken place within a short distance of the Broad Street water pump. This not only led to pinpointing the pump as the source of infection but to Snow's discovery that cholera is spread by contaminated water rather than the miasma that was generally thought to be the culprit.

Smart planning and decision-making is not new, but the volume of data and the speed of analysis today allow us to react more quickly and act more smartly.

The recent study on tall buildings by the NLA illustrated the impact that new towers were having on the capital. It was clear from the furore that followed that few people were aware of the totality of future projects. A 3D computer generated map of new developments would have been able to inform politicians as well as the general public precisely what was planned. Such a 3D model could also – as does the computer model of Seattle by Parsons Brinckerhoff – include a whole lot more information including underground infrastructure as well as overground and information about the movement of people, power and water.

The GLA already has a plan to generate a 3D map of all London's underground assets, requiring significant levels of collaboration between different parts of the built environment industry. Why not do the same for overground assets? The release of Ordnance Survey 1:1250 mapping data would assist in the delivery of such integrated models and visualisation projects.

The way that design professionals will most generally integrate with such digital mapping will be via BIM. Although there has been considerable growth in the take up of BIM over the past five years, the NBS National BIM Report raises concerns that there is still a lack of clarity about BIM, a real need for more training and a fear that smaller firms feel excluded. It should be a priority of the industry to ensure that BIM is widely understood and adopted.

As this study makes clear, there is a vast and increasing amount of material about smart cities and many organisations struggle to keep up with its development. An online Building Industry Forum is needed where problems and ideas can be shared between industry experts and a library of smart projects and reports can be created. The smart city is not the invention of large corporations selling computer technology or control systems. A smart city and thus a Smarter London is one where citizens, managers and suppliers make intelligent use of technology and data about the way the city works in order to improve efficiency and liveability and to reduce waste and carbon emissions.

Technology and data themselves cannot produce smart solutions; for the time being at least, intelligent human interventions will be required to produce the sort of city we want to live in. As Philip Dyer of Atkins has said 'Cities aren't smart, people in cities are.'

Project Showcase

The following pages present a selection of smart projects being delivered by built environment teams in London – including projects based within the capital itself, and those undertaken further afield.

In defining ‘smart’, all projects were asked to meet at least three of the following criteria:

— Intelligent use of technology or data analysis to solve a problem;

— Responsiveness to real-time conditions;

— Integration of information from a number of stakeholders or sources to deal with a complex issue;

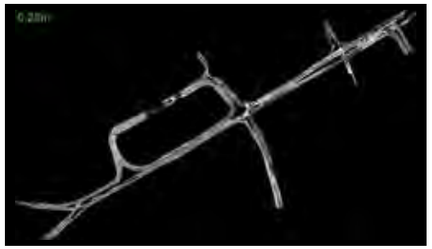
— Reducing overuse of resources; improving efficiency, energy use or waste;

— Applying new thinking to an issue, avoiding unnecessary over-complication.

NLA, supported by Derwent London and Bloom Worldwide, also invited technology companies and small start-ups to tell us about innovative new products that are being developed to aid the built environment industry to develop smarter projects. A selection of their products are showcased here.

Key

- London-based
- UK or International
- Product



Aldgate Enhancement Radar Surveys

In use, completing in January 2017

During pre-planning for the Aldgate Area enhancement project, the City of London used extensive radar surveys of both underground utility plant and carriageway concrete to deliver efficiencies for the scheme. A three-dimensional 'fly-through' model was created to help illustrate how the many pipes, cables and ducts overlapped below ground. This saved time and money as clashes between scheme designs, temporary works and utility equipment were identified and resolved early on. Radar surveys revealed road construction weaknesses, giving a better understanding of the anticipated extent, duration and cost of works.

Client & Project Manager:
City of London Corporation
Construction: JB Riney & Co Ltd
Subsurface Imaging Provider:
Macleod Simmonds

Alpha Square

Design stage, due to complete Q1 2019

This 67,000sqm development in South Quays aims to integrate market and affordable residential with a hotel, health centre and new primary school, encircling a new public space, Alpha Square. The design has drawn upon sophisticated parametric modelling tools to optimise the form of the floorplate and the facade. A form-finding algorithm was built to refine the form of the floorplate against the complex mixed-use brief, utilising an evolutionary evaluation process that scored plan alternatives. Those that delivered closest to the brief criteria then formed the basis for the next generation of evaluation.

Client: Far East Consortium International Limited (FECIL)
Architect and Masterplanner: Pilbrow and Partners
Project Manager: Southern Grove
Structural Engineer: WSP
MEP Engineer: Grontmij
Planning & EIA Consultant: JLL
Cost Consultant: Tower8
Transportation: Momentum Transport Planning
Rights of Light/Daylighting: Gordon Ingram Associates

BIMCabin for Immersive Visualisation in Construction at Stonebridge Site 10

Under development, due to complete October 2015

The BIM revolution makes more efficient use and reuse of design and construction data, with reduced waste in the processes and the potential for better communication. The BIMCabin, currently being developed and trialled by four partners in the TSB-supported Immersive Visualisation in Construction project, provides a multi-screen set up in a site cabin that gives access to multiple sets of data simultaneously. Whether for marketing, safety briefing or technical coordination, this facility hopes to support the drive for better building faster.

Client: Hyde Housing
Architect & Research Lead Partner: Cullinan Studio
Hardware & Software Developer: HoloVis International
Academic Research Partner: Warwick Manufacturing Group
Building Contractor: Durkan Construction Ltd

199 Bishopsgate

Completed September 2012

Undertaken with sustainability and energy efficiency as key considerations, this refurbishment resulted in an annual carbon emissions drop from 939 to 361 tonnes, reduced water and energy consumption and the introduction of sedum roofs to encourage biodiversity. A record 98 per cent of construction waste was diverted from landfill through careful monitoring. A 'calibrated' energy model was built early on in the programme, allowing the design team to develop mock-ups and set benchmark areas. Data was used to predict occupant energy use and provide a calculator tool.

Client: British Land
Project Manager: M3 Consulting
Architect: John Robertson Architects
Building Services Engineer: Chapman Bathurst
Structural Engineer: Meinhardt
Cost Consultant: Sense
Planning Consultant: DP9
Sustainability Consultant: Greengage
CDM: Capita Symonds

Bliive

Completed May 2013

Bliive is a collaborative social network for time exchange – using time as currency for the exchange of services and experiences. Over 45,000 people are currently using the network in 80 countries. Having recently moved to the UK as part of Sirius Programme, the free platform hopes to make London's inhabitants use their time wisely, in a collaborative way – giving people the chance to learn and teach new things without having to spend money.

Designer & Developer: Bliive

Braci – The Smart Ear

In use, completed August 2014

Braci – The Smart Ear has developed a solution which is capable of detecting a wide range of sounds which are then pushed as easily understood notifications through a smart device (phone &/or watch). The Smart Ear is used to notify its users of their environmental sounds (such as doorbells, fire/smoke alarms, telephone ringing, baby crying, intercoms) by recognising and analysing sounds from the surroundings and then converting this data into a variety of vibrations, notifications, and flashing lights. Braci detects sounds through recognition of the sound itself instead of the traditional method of receivers and transmitters – this was only achievable having created a unique and patented fingerprint for each sound.

Designer: Braci

CADBEAM

Under development, due to complete September 2014

Members of the UKTI's Sirius Programme, CADBEAM is a mobile application for construction management that allows clients and contractors to view in real-time what is going on in their construction projects and improve coordination on-site. Thanks to tablets and smartphones, contractors can manage their subcontractors easily and compare their progress with the project schedule to see if they are late or on time.

Developer: Basaltis Ltd
Consultants: Costain Group, VINCI Energies, LIDL Supermarkets

City of London Mobile Working for Street Works and Highway Inspections

In use

With the introduction of mobile technology and handheld tablets, the City of London has enhanced the way it inspects and manages the highway. The inspector on-street receives better information, including the conditions imposed on current street works, and details of future works and road closures, improving control and co-ordination. For highway repairs, more in-depth management information on the location, prioritisation and repair times for defects is available, which improves long-term efficiency planning and budgeting for highway maintenance works.

Client & Project Manager:
City of London Corporation
Software System:
Insight Mobile by Symology Ltd
Tablets: Panasonic Toughpads

Croydon – London's first intuitive district

Project Status: Strategy in place – three of five pilot projects in development

Faced with a £100 million savings requirement over the financial years 2014-2017, Croydon is conducting a root and branch review of service provision to identify efficiencies and savings as part of the 'Croydon Challenge'. As part of this process, Croydon is identifying the scope for developing digital & online services that reduce the costs of delivery by, for example, using the internet, mobile devices and apps that allow service users (residents, businesses and visitors) to utilise the services they require at times and methods most convenient for them as customers and consumers.

To this end, the Council is developing a pilot programme with three core objectives:

- Provide the infrastructure to develop Croydon as a location for technology businesses
- Develop digital services that reduce transaction costs of customer interface with the Council
- Use new technology applications to deliver service improvements and efficiencies that will produce longer term savings

This approach would be a fundamental change to how local government assesses and delivers services for its residents, businesses and visitors. LB Croydon intends to use these pilot projects to demonstrate how they can do more with less by using a more intuitive, customer led approach to ensure the right resources are used in the most efficient way for the benefit of all of Croydon. The five pilot projects are:

Telehealth services in Croydon (with GLA)
Using a mobile app linked to people's smartphone to monitor longterm conditions such as diabetes – a major challenge for health services in Croydon. These projects aim to deliver service improvements and efficiency savings to contribute to the challenge.

Integrated parking & traffic management
The redevelopment of Croydon town centre offers a unique opportunity to develop a technology-driven, fully-integrated parking and traffic management system.

Preventing NEETs
Introduce analytic software within youth service and schools to more accurately identify year 9 & 10 students likely to become NEETs.

Croydon Code Clubs
Develop programming skills via Code Clubs in all Croydon primary schools.

Improving broadband infrastructure
A recent study of the broadband infrastructure in Croydon revealed that the area is lacking in high-speed connectivity.

Based on the success of these projects over the next three years, the Council would then look to roll out the expansion of digital enabled service throughout its services.

Project Team
Project Manager: LB Croydon

"The importance of the digital sector in Croydon should not be overlooked in terms of it's ability to deliver jobs and growth and the efforts to develop an overall Digital Plan by Croydon proving a strategic fit are perceptive."
Gary Ling, Digital Consultant, TraderSURE

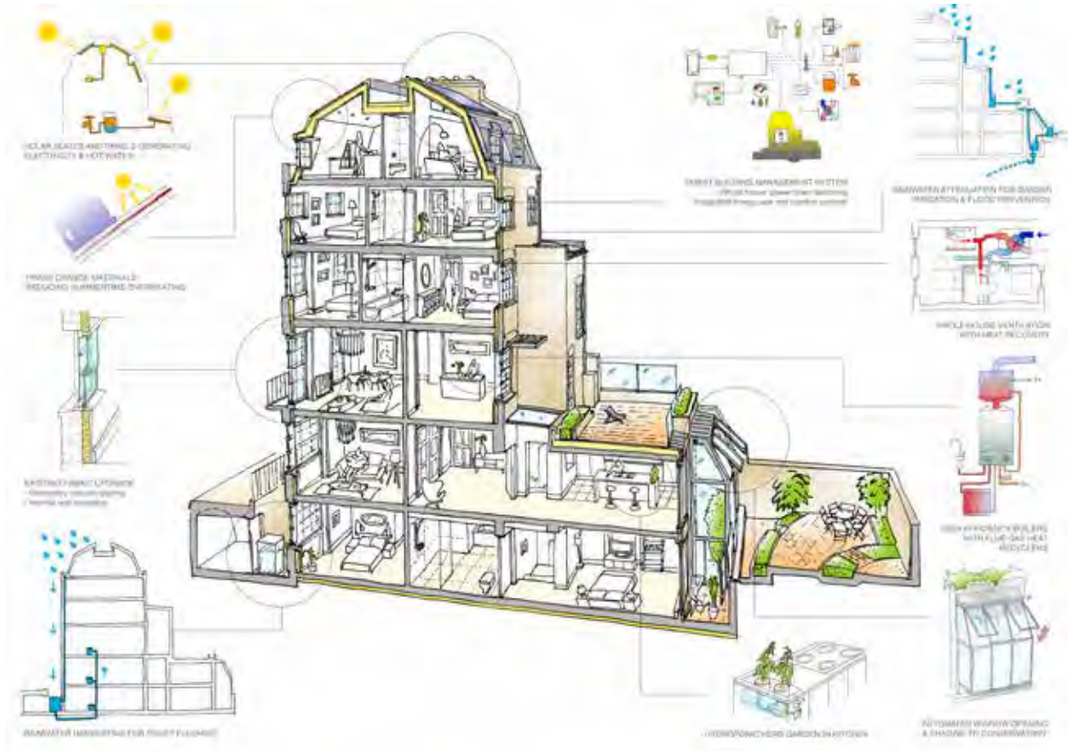
"Croydon Council is working with partners including the GLA to develop a Smarter Croydon programme, which we believe will result in both service improvements and efficiencies, through, for example, the healthcare monitor and management project; this will also contribute to the wider GLA Smarter London Plan."
Lisa McCance, Head of Economic Development, London Borough of Croydon

Cllr Toni Letts, Cabinet member for Economic Development
Borough of Croydon

The London Borough of Croydon is home to the fastest growing tech cluster in London. Since 2011, the tech sector has expanded by 38 per cent over the past two years to become the seventh biggest and fastest growing of London's tech clusters. There are now 255 tech businesses in Croydon Opportunity Area – 1,035 across the borough – and if the trend continues, Croydon is projected to be the fifth biggest cluster in London by 2015, outpacing Hammersmith and King's Cross, amongst others (ONS UK Business Counts MSOA level, April 2014). The London Borough of Croydon is determined to make the most of these talent and skills to make the way we deliver services to our residents and businesses better and more efficient, and our Smarter City Strategy is at the heart of the programme.

119 Ebury Street

Address: Belgravia, London SW1
Project Status: Under development, due to complete April 2016



Exploring the balance between the goals of low carbon sustainable retrofit and conservation of historic building fabric, the development at 119 Ebury Street is a highly sustainable refurbishment within a heritage context, comprising of a change of use from a hotel to create three residential duplexes. The sustainable refurbishment contains a number of 'smart' technologies, providing data on environmental performance and building operational functions.

The new sustainable 'smart' technologies introduced needed to be both sensitive and appropriate to the historic fabric of the building. They include internal wall insulation to existing walls; secondary vacuum glazing to existing windows; phase change materials to mitigate overheating; improvements to air leakage; rain water harvesting; renewable energy generation from PV and solar thermal panels.

Grosvenor are working with Perfect Integration Ltd and will be installing a Building Management System (BMS) with user friendly smart controls. The BMS uses sensors to record room temperature, relative humidity, dew point, carbon dioxide concentration and energy consumption. The captured data is stored on servers and is available to download for a variety of time periods, providing easy to use user feedback and occupant-control interfaces.

Integral to the scheme is a detailed two-year post-occupancy monitoring and reporting programme, to measure the success of the initiatives in terms of user satisfaction and carbon reduction. The performance of the scheme is benchmarked against a nearby similar listed building, 125 Ebury Street which has been refurbished to a Grosvenor standard specification and will be monitored simultaneously.

The post-occupancy monitoring data collection covers:

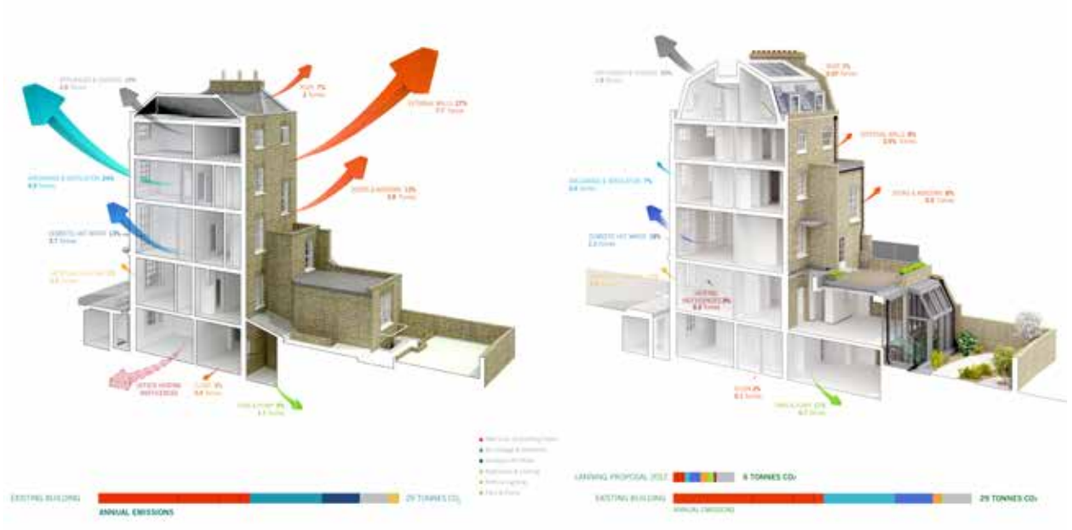
- Consumption rates of fuel and water, broken down by end use (heating, hot water, lights and appliances) with associated costs and CO2 emissions
- Environmental conditions inside the apartments (temperature, humidity and CO_2 levels) and local weather data from a roof-top station
- Environmental conditions within the fabric of the existing walls, (temperature and moisture content) to assess any change in condensation risk to the insulated walls.

"It is important to have test projects which can be rigorously examined with academic scrutiny in order to expand existing knowledge and better inform industry about what works, what doesn't and where more research is needed. 119 Ebury Street will provide much needed data regarding the performance of interventions for the energy efficient retrofit of historic properties."
Kayla Friedman, Deputy Director of the Interdisciplinary Design for the Built Environment (IDBE) Master's Programme at the University of Cambridge

Project Team
Developer, Client & Project Manager: Grosvenor
Architect: David Morley Architects
M&E Engineer: Edward Pearce and Partners
Smart Technology Specialist: Perfect Integration Ltd
Energy Performance Consultant: Rickaby Thompson Associates Ltd
Sustainability Consultant: Eight Associates
Structural Engineer: Hurst, Peirce and Malcolm LLP
Contractor: Grangewood

James Starr, Development Manager
Grosvenor Britain & Ireland

119 Ebury Street aspires to be the first UK listed building to reduce its carbon emissions by 80 per cent, meeting the 2050 national target by 2016. The project will test a variety of 'smart' technological enhancements, including the appropriateness of their incorporation within a heritage building.



"Westminster welcomes this project that explores and tests emerging technologies and could deliver improved energy efficiency in our heritage assets. The monitoring and gathering of data on energy efficiency measures in schemes such as 119 Ebury Street is vital. It will further our understanding and knowledge on how our heritage assets deliver reduced energy need and therefore reduced running costs. The retrofitting of buildings such as 119 Ebury Street will be especially crucial in areas like Westminster due to the high proportion of heritage buildings that form part of Westminster's uniqueness. The outcome from this project will help inform policy and future projects."
Cllr Robert Davis DL, Deputy Leader and Cabinet Member for the Built Environment, Westminster City Council

Elephant Park

Address: Elephant & Castle, London SE17
Project Status: Under construction, phased delivery between now and 2025

Lend Lease is working in partnership with Southwark Council to deliver a transformative £1.5 billion regeneration project in Elephant & Castle, providing almost 3,000 homes, new shops and restaurants, and a new park right in the centre of the development. The plans are seeking to use the vast scale of the project to tackle some of the most challenging issues currently facing cities like London, from providing greener transport options to stimulating economic growth.

As part of this ambition, technology will play a fundamental role in providing a platform to deliver the vision of a smart Elephant Park. For example, the provision of enhanced Wi-Fi and mobile phone coverage throughout the development is being investigated, to allow connectivity and to support applications that will deliver the aspiration of a more sustainable and inclusive development.

The scheme will also consider how technology will support a greater sense of community and belonging, such as the use of social media to inform and engage on sustainable transport opportunities, local events and services and to promote a greater sense of sharing as part of a more sustainable lifestyle.

Elephant Park is one of only 18 founding projects globally to be part of the Climate Positive Development Programme – which commits the development to be Climate Positive by 2025 – so a key part of the development process has involved the investigation of smart ways to raise awareness of the various sustainability features that will be delivered across the scheme, together with real-time information on the energy efficiency of the development.

Technology will also be considered to support and enhance local services, shops and restaurants, to keep Elephant and Castle's rich cultural lifestyle and to promote Elephant Park as a key London destination.

Efficiencies in estate management operation can also be achieved through the use of smart technology, to reduce the development's operational carbon footprint and provide more services and information to the Park residents. A key aspiration will be to facilitate more mobile working of estate management staff, using technology to provide enhanced services to residents and visitors.

Taken together, these commitments to a smart Elephant Park will not only make the Elephant a great place to live but will influence how Lend Lease delivers other major urban regeneration projects in the future.

"Our world leading plans are seeking to use the vast scale of the project to tackle some of the most challenging issues currently facing cities like London."

"Commitments to a smart Elephant Park will not only make the Elephant a great place to live but will influence how Lend Lease delivers other major urban regeneration projects in the future."

Project Team
Client: Lend Lease, in partnership with Southwark Council
Developer & Contractor: Lend Lease
Architects: Make, Maccreanor Lavington Architects, Allford Hall Monaghan Morris (AHMM), Panter Hudspith Architects
M&E Engineer: Waterman (EIA)
Planning Consultant: DP9
Project Manager & Cost Consultant: Gardiner & Theobald
Townscape: Tavernor Consultancy
Transport: Arup
Residential: Savills

Nigel McKay, Innovation Lead
Elephant Park, Lend Lease

Our world is evolving. The trend towards rapid urbanisation and the conditions within megacities are creating new challenges for communities. That's why at Lend Lease we challenge ourselves every day to take the long-term view and to continually evolve and improve our thinking and practices so that we leave behind genuinely sustainable legacies. Elephant Park is a big project, bringing us a unique opportunity to create positive change and to harness the scale of the scheme to address pressing local and global challenges around climate change, housing, health and employment. The use of digital technologies in creating a smart Elephant Park will play a vital role in helping us to deliver this ambition.

Commonplace London Bridge

In use, final report due January 2015

Team London Bridge (TLB), with support from Southwark Council, is developing an Action Plan to champion local aspirations and concerns. Selected for its simplicity, Commonplace designed and delivered a specific iteration of its web-based platform for public engagement. This allows people to visit the website and place a marker on the map to show their location of interest. The resultant interactions help forge suggestions and strategies for the Action Plan, with consultation data available to TLB in real time.

Client: Team London Bridge and Southwark Council
Developer: Commonplace

Conceptual 3D design of Crossrail South-East Section

Under development, due to complete 2018

Conceptual 3D multi-disciplinary designs influenced the approach to the construction works for the south-east section of Crossrail. Helping to shape a safe and efficient railway for the 21st century, the designs focused on a critical two-mile stretch from Plumstead to Abbey Wood, including design of the new Abbey Wood station, the terminus station on the south-east section of the Crossrail route. The 3D design model supported progressive design integration and early construction sequence reviews. It carries vital asset data information, and its integration into a 5D-CAD environment will benefit programme planning, including cost and risk.

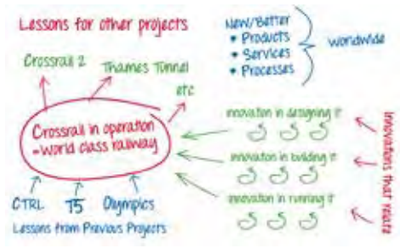
Client: Network Rail
Contractor: Balfour Beatty
Initial Programme Manager & Lead Designer: Parsons Brinckerhoff
Abbey Wood Station Architect: Fereday Pollard
Abbey Wood Station Structural Engineer: Tony Gee & Partners

Crossrail Information Management and Digital Technology

Under development, full service in December 2019

Accessible to everyone working on Crossrail, linked relational databases have formed a Common Data Environment that holds all design, construction and asset information that aims to pass seamlessly into operation and maintenance, generating significant efficiencies and reducing waste. Visualisations for construction sequencing using 4D models have saved millions of pounds in reducing complexity and risk, and improved safety. All assets have a data-rich barcode and, linked to the databases, will leave a lasting physical and digital legacy for London.

BIM Project Contributors:
Crossrail Ltd, Bentley Systems Ltd, Bechtel Ltd, Synchro Systems, Wagstaff Design, Fujitsu

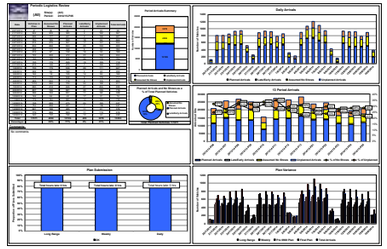


Crossrail Innovation Programme

Under development, due to complete December 2018

This legacy programme has invested approximately £300,000 in 30 innovation projects, and has published over 230 practices. The programme is using data and technology to provide innovative solutions, including: research into Low Carbon Concrete and Lightweight Aggregate, reducing carbon footprint and recycling requirements; using fibre-optics and Bluetooth Low Energy Beacons to provide digital construction environments; delivering recycled energy to London buildings and optimising energy consumption.

Crossrail Innovation Partners include: Murphy, Laing O'Rourke, Vinci, COMIT, Bam Nuttall, Kier, Ferrovial Agroman, Morgan Sindall, Dragados, Costain, Skanska



Crossrail Vehicle Movement Planning System (VMPS)

In use

Crossrail needs approximately 2,000 vehicle movements a day, supporting 47 construction sites across central London. To improve the projects logistics management, the VMPS was developed – enabling over 400 users to plan vehicle deliveries through a web application, recording real-time vehicle safety and arrival rates via Personal Data Assistants. This allows a complicated logistics task to be co-ordinated centrally: reducing traffic congestion – minimising the impact on London's streets, increasing efficiency and improving vehicle safety by analysing and sharing information amongst stakeholders.

Developer: Crossrail Ltd
Delivery Partners: Transcend and Bechtel

33 Davies Street

Completed December 2013

Utilising BIM to design and co-ordinate the construction information, a detailed data model was drawn up comprising of the cladding, structure, mechanical and electrical services and all architectural elements. The pre-cast cladding was developed using this advanced data model and constructed off-site, and then delivered to site on a 'just in time' basis, allowing the facade to be constructed in six weeks as opposed to 20 weeks if traditional methods had been employed. This allowed a much reduced construction period, and a cleaner, safer site environment with no need for external scaffolding.

Developer: Grosvenor Stow Projects 2 Ltd
Architect: HOK
Structural Engineer: Ramboll UK Ltd
M&E & Sustainability Engineer: MTT
Quantity Surveyors: AECOM
Contractor: Sir Robert McAlpine Ltd
Planning Consultant: DP9
CDM Coordinator: Capita Symonds

Custom Build Homes

Design stage

Creating unique house designs which are able to be customised and be delivered as a complete built package to the customer, the masterplan for Trevenson Park South in Cornwall includes a mix of 2-, 3-, and 4-bedroom adaptable houses in terraces, semi-detached pairs, and detached houses. The accompanying Design Code sets out the urban design and plot parameters for this sensitive regeneration site. Recently, permission has been granted for a Custom Build PassivHaus which will cater for a growing interest in highly sustainable design among Custom Build customers.

Client: Carillion Igloo
Masterplanner, Architect, Urban & Landscape Designer: HTA Design LLP
Contractor: Kingspan Potton

Delivering the Goods for Regent Street

In use

The Regent Street Delivery Consolidation Scheme has reduced delivery trips by 74 per cent, CO_2 by 10 tonnes per annum, and improved air quality and reduced noise on this busy street. Since its implementation, there has been an 80 per cent reduction in lorry movements associated with Regent Street. The Swallow Street Refuse Scheme has reduced refuse lorry movements by 75 per cent and increased recycling rates to over 70 per cent. The Preferred Supplier Scheme reduces office deliveries of frequently ordered commodities by negotiating economical prices with preferred suppliers, all delivered using zero emission vehicles.

Client: The Crown Estate
Advisor: Arup
Scheme Manager: Regent Street Management Direct
Preferred Supplier Scheme: Gnewt Cargo
Freight Consolidation: Clipper Logistics

Green Energy by The Crown Estate

Address: Quadrant 3, Regent Street, London W1
Project Status: Completed October 2013

The £400 million BREEAM Excellent Quadrant 3 scheme on Regent Street aims to be a model for sustainable central London development, incorporating substantial public realm improvements as well as a sophisticated energy generation system. Quadrant 3 is the first development in the UK to install a highly efficient and sustainable fuel cell that draws its power from the same technology that was used to provide energy to NASA space shuttles during flights.

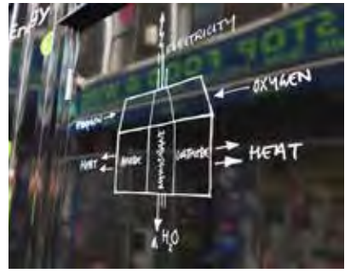
Emitting 38 per cent less carbon dioxide than using electricity from the grid and heat from gas fired boilers, the 300KWe molten carbonate fuel cell is the most efficient of its kind in Europe. The fuel cell forms part of one of the world's most sophisticated central energy systems which serves over 46,500 sqm of offices, retail, residential, restaurant and hotel space in the Regent Street Quadrant area. The cell converts natural gas into electricity through an electrochemical process which avoids creating any of the by-products of combustion, drastically reducing environmentally harmful emissions. A projected 350 tonnes of carbon dioxide emissions will be saved per year.

As well as reducing the building's carbon footprint, the electrochemical process makes the cell highly efficient as no energy is wasted between the power station and the building, or in moving the mechanical parts needed to induce combustion. Logan Energy, who installed the cell, estimate that the overall efficiency of the installation is at 83 per cent but with a higher electrical contribution than other types of distributed generation.

The quiet operation and virtual lack of pollutants from fuel cells has allowed the cell to be physically located inside the building, demonstrating its useful application in urban areas.

The fuel cell supports the targets established by the Mayor of London to supply one quarter of London's energy from decentralised sources and reduce CO_2 emissions by 60 per cent by 2025, supporting the Mayor's vision for London to be the greenest big city in the world.

"This project demonstrates that fuel cell based energy centres are able to compete with all other forms of distributed generation even without government subsidy and will play an increasingly significant role in the reduction of carbon emissions and electrical power resilience in the UK"
Bill Ireland, Chief Executive and Chairman at Logan Energy Ltd



Project Team
Client: The Crown Estate
Development Manager: Stanhope
Architect: Dixon Jones
Main Contractor: Sir Robert McAlpine
Fuel Cell Installation: Logan Energy
Mechanical & Electrical Consultant: AECOM

Alastair Smart, Head of Development and Project Management
The Crown Estate

The Crown Estate's long term outlook means that sustainability is a critically important part of our approach to business. Reliable on-site power generation delivered in an environmentally friendly manner is an important aspect of our development projects and the fuel cell fits our requirements at our Quadrant 3 development on Regent Street.

Occupiers are increasingly looking to operate more sustainably and this includes factoring in the green credentials of their premises. The fuel cell is a real flag in the sand, demonstrating what is possible in terms of energy efficiency and carbon reduction, and it will only enhance the building's reputation as a world-leading example of sustainable development.

Grosvenor EnerPHit (Passivhaus) Retrofit

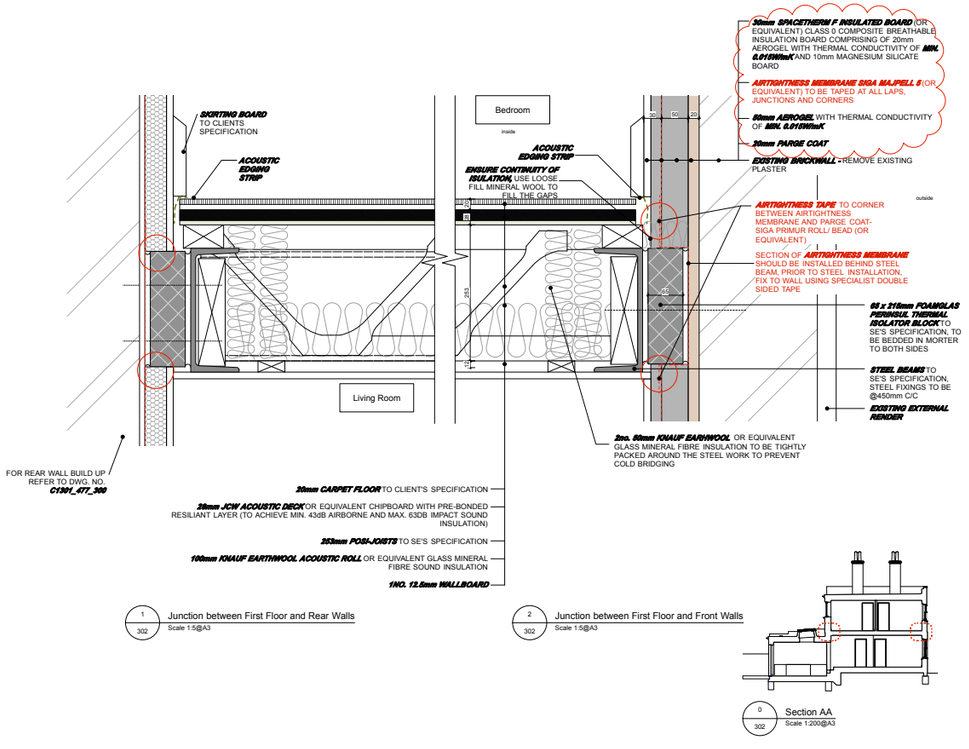
Address: Various in SW1 and W1
Project Status: Under development

This year Grosvenor commissioned five 'smart' historic retrofit projects in London designed to achieve the EnerPHit standard, the world's leading sustainability standard for refurbishment that employs passive house principles.

All five buildings are typical London terraces with attractive brick frontage and traditional single glazed windows, and therefore the interventions had to be responsive to the existing conditions. For that reason, intelligent new technologies and materials were used, including: ultra-slim, breathable and super-efficient aerogel internal insulation boards, breathable but moisture proof intelligent airtightness membrane, one of a kind triple-glazed mock-sash windows made locally, concealed low-maintenance self-balancing Mechanical Heat Recovery Ventilation unit and Hidden Solar Voltaic panels that brought energy use down to Carbon Zero.

The building designer had to ensure that the criteria are achieved using various data analysis tools, such as PassivHaus Planning Package (PHPP) energy modelling tool, WUFI transient hydrothermal behaviour software that calculated realistic moisture deposit levels from internal condensation and London precipitation patterns, and THERM software used to complete 32 detail cold bridging calculations that evaluated the heat flow through various construction junctions.

The key consideration on this project was not only to improve the current building energy efficiency but also to learn about both the process and the outcome of various measures. A number of monitoring devices were installed in the building to measure temperature, relative humidity and carbon dioxide levels that test the 'guaranteed' comfort levels and energy efficiency of the building and moisture meters collecting the water build up measurements inside the building fabric, which forms part of a wider study aimed to outline the risks of internal insulation in historic fabric. These should ensure that Grosvenor uses smarter specifications in all future refurbishment projects.



Victoria Herring, Director of Refurbishment and Retrofit
Grosvenor Britain & Ireland

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Project Team
Client & Project Management: Grosvenor
Architect / Certified PassivHaus Designer: Sturgis Carbon Profiling LLP
Contractor: Grangewood
Quantity Surveyor: Thomson Cole

Grosvenor Sustainable Retrofit Dashboard

Address: Mayfair, W1 and Belgravia, SW1
Status: In use, due to complete in 2023

The Sustainable Retrofit Dashboard is a tool that Grosvenor is developing to track progress against targets in their Sustainable Retrofit Programme. This dashboard will concentrate and simplify information input and automatically analyse data to account and report results.

Following the top-down approach to retrofit defined by Grosvenor, the dashboard will use smart systems, technology and data analyses to efficiently predict, track and account results at every stage of the programme, avoiding unnecessary duplications. This tool will reflect Grosvenor's comprehensive methodology towards sustainability – including environmental, economic and social factors.

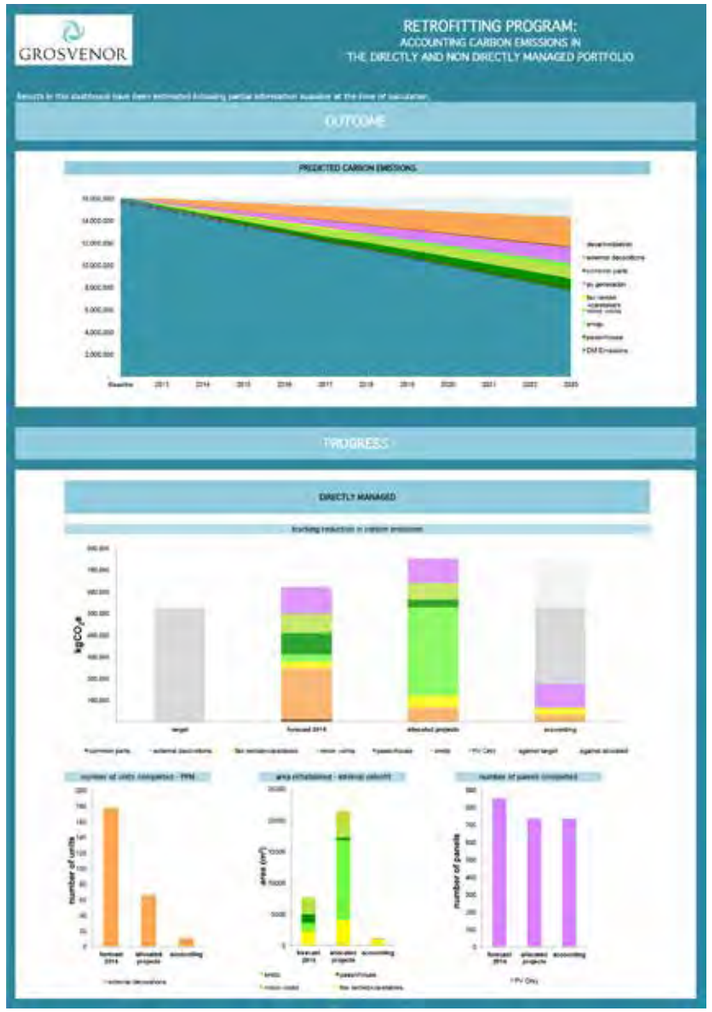
In order to assist Grosvenor to achieve their carbon reduction targets, the dashboard includes a prediction and tracking of carbon savings and budget allocation using smart strategies such as building performance evaluations.

To support Grosvenor's economic business cash, the dashboard tracks direct cash flow, increased asset value capitalised in rent premiums, void reduction, tenant retention and procurement efficiency savings. Smart Strategies to support this include Marginal Abatement Cost Curves, extensive analyses of transactional values in Grosvenor's markets and Hedonic Regressions.

To reflect the benefits for the community, the dashboard tracks reduction of tenant's energy bills, tenant satisfaction and engagement using smart strategies such as wireless monitoring, post-occupancy evaluation surveys and home display units.

All the information input into the Sustainable Retrofit Dashboard builds an invaluable database for Grosvenor that enables further complex analyses – GIS, econometrics – to unearth opportunities and critical areas of improvements that aims to keep the estate at the forefront of the property market.

Project Team
Developer & Asset Manager: Grosvenor
Carbon Analysts: Sturgis Carbon Profiling LLP



Victoria Herring, Director of Refurbishment and Retrofit
Grosvenor Britain & Ireland

Grosvenor have set an ambitious target to reduce carbon emissions by 50 per cent from our directly managed portfolio between 2013 and 2023. The challenge is that our portfolio is substantial and consists of period buildings, 90 per cent of which are in a conservation area and a large number of which are listed. Many of the properties also remain in occupation during the retrofit works. We aim to improve the energy efficiency of approximately 150 units a year by integrating improvements into the existing refurbishment and planned maintenance pipeline, in addition to undertaking standalone projects such as the installation of solar panels. The Retrofit Dashboard enables me as Director of the Programme to make informed decisions to keep us on track to meet our target.

"Grosvenor's top down approach to retrofit allows the delivery of the least disruptive and most cost efficient roll out of retrofit across their estate, helping to maximise carbon savings whilst minimising capital spends"
Gareth Roberts, Partner, Sturgis Carbon Profiling LLP

DC Desk

In use, completed April 2014

All IT devices use low voltage direct current (5V/12V/24V), yet offices distribute power at alternating current (240V), which requires all devices to convert locally from AC to DC. Hoare Lea has recently installed a pioneering prototype DC desk in their London office, and acts as a demonstration of the emerging trend towards the use of direct current (DC) in place of conventional alternating current (AC). The desk enables DC to be supplied to a number of devices without the need for individual power adaptors, making the use of DC-reliant technology easier in the workplace. The system has been developed with Moixa Technology based on their Maslow system and their DC components.

Developer: Hoare Lea

Earls Court Masterplan

Phase 1 under construction, masterplan due to complete in 2030

Based on the belief that urban developments should blend in with existing urban settings and communities, a five-stage community engagement programme was begun at an early stage of this project and will continue throughout the planning, development, construction and occupation. As well as numerous exhibitions and events, the My Earls Court website created an online forum which was a first for a project of this scale and complexity. The website has been an interactive hub which has facilitated dialogue between the project team, residents, community groups and stakeholders.

Client: Capco
Masterplanner: Farrells

Foyles

107 Charing Cross Road, London WC2

A key element of the 'bookshop for the future' vision Foyles adopted for its new store on Charing Cross Road, Ariadne is the UK's first 'bricks and mortar' digital book search. The Ariadne landing page appears when a smartphone connects to the store's Wi-Fi network, and allows customers to search for title or author. Real-time search results not only tell the customer whether a book is in the store but will point them right to it – by way of a Google-style map of the seven-storey flagship with the route plotted on it. The 'app-style' search makes the in-store shopping experience seamless without detracting from the pleasure of book browsing.

Architect:
Lifschutz Davidson Sandilands
Digital Agency: White October

GIS at King's Cross

Under development, due to complete 2020

The development site is subject to several encumbrances, from rights of way and asset protection provisions that arise from the historic and continued presence of railway infrastructure, to leases and licences. GIS is used to monitor building completion dates and make long-term business decisions, such as when to commence the marketing of newly completed buildings. The tool not only allows the mapping of data, but also influences the process of creating new inputs, linking data with reports and external sources of information and sharing information within project teams.

Developer: Argent, as part of the King's Cross Central Ltd Partnership

EVSTAT Station

Design stage

The Electric Vehicle Rapid-Charge Station (EVSTAT) has been designed to serve the fast-emerging electric vehicle market, with the concept being tested in the US. The station can fully charge an electric vehicle in under 25 minutes using high voltage DC charging. This new building typology would also provide Club-Class relaxation areas that impart essential business services for the early adopters of on-the-go lifestyles, together with retail and vehicle rental spaces, refreshments and seamless wireless connectivity.

Client: Evoasis
Architect: EPR Architects

Fifty Grosvenor Hill

Completed May 2012

An existing terraced block of eight buildings from different periods has been combined and transformed into a single 2,000sqm open plan building, providing new energy efficient offices of the highest quality and specification. The building's open loop borehole brings cooling from the natural aquifers found under Mayfair and passes them through the building's heat change system, while excess heat is absorbed by the building's exposed concrete soffits and dissipates back into the building overnight. In addition, the chilled beam system, double-glazed windows, programmed intelligent lighting, and head-absorbing concrete soffits make sustainability second nature.

Developer: Grosvenor Britain & Ireland
Architect: GMW Architects
Main Contractor: Sir Robert McAlpine
Services Engineer: Hoare Lea
Structural Engineer: Ramboll UK

GL Hearn mapping tool

Under development, due to complete October 2014

Making optimum use of land for new homes and jobs is a key challenge to manage London's growing population. To this end, this tool has been developed to identify major new opportunities for densification in accessible locations across Greater London. The map-based system will be the first to combine data from several different sources to locate major opportunities at an early stage and prior to any planning being significantly advanced.

Developer: GL Hearn

Guy's Tower Retrofit

Completed May 2014

The recladding of Guy's Tower – the tallest hospital in the world – was necessitated by parts of the concrete facade flaking off and endangering all below. The design began with dynamic thermal modelling of energy and carbon with IES software and calibrating the data via sampling of actual energy use via sub-meters installed for the purpose. Alternative facade solutions were then modelled in the same way to select the optimum one. The cladding installation used purpose-designed access technology allowing occupants to remain in situ throughout. The new skin of lightweight folded aluminium, insulation and glazing will recoup its embodied energy in eight years and contribute an 18 per cent energy saving.

Client: Essentia, Guy's & St Thomas' NHS Foundation Trust
Architect: Penoyre & Prasad
Lead Consultant, Project Manager, Facade & Structural Engineering: Arup
Contractor: Balfour Beatty
Access & Scaffold: Harsco
Facade: Permasteelisa
Metalwork: Ironman
Concrete: Kafften

Hammersmith Flyover – Engineering solutions

Project Status: Under construction, due to complete Summer 2015

Hammersmith Flyover is one of eight key structures in London that form Phase 1 of Transport for London's (TfL) Structures and Tunnels Investment Portfolio (STIP). STIP is part of TfL's Road Modernisation Plan which will see £4 billion invested in surface transport infrastructure to make journeys safer and more reliable, and to improve the environment for all users of the network.

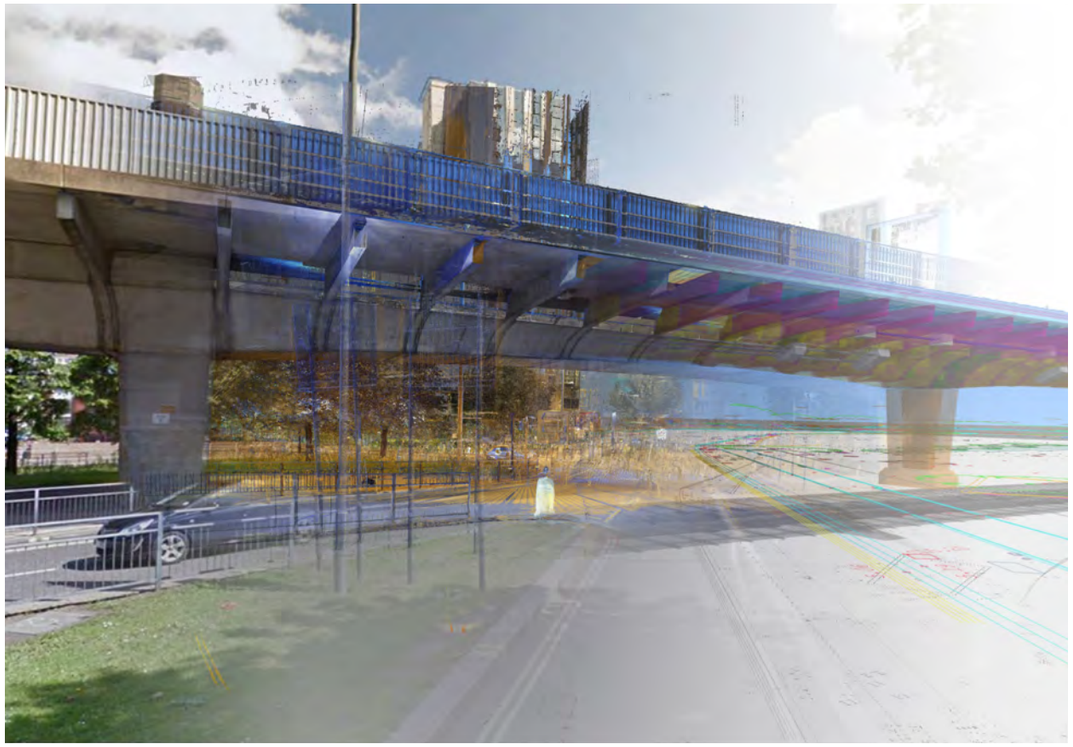
Prolonging the life of the iconic Hammersmith Flyover is of critical importance to TfL. This key strategic route into London sees 90,000 users every day, and the structure presents many technical, logistical, programme and political challenges. Successful collaboration and effective deployment of technology have played a key role in meeting those challenges, delivering technical innovation and facilitating an accelerated delivery programme.

3D modelling has been used extensively in the design and construction methodology. Access to the flyover is limited by the geometric constraints of the bridge and its strategic location on London's road network. A combination of 'as built' records and advanced laser scanning has informed a detailed 3D model of the structure, enabling virtual access at any time and with no disruption to traffic.

The model has helped inform, verify and challenge design assumptions, test construction scenarios and understand the many interdependent elements of work. A key benefit has been the collective understanding of compatibility between new elements of work and the existing structure. Targeted physical surveys and identification of key risk areas have been driven by the model.

Strengthening works to Hammersmith Flyover are underway. New post tensioning is being installed, bearings are being replaced, drainage is being changed and improvements made to road restraint systems, finishing with waterproofing and resurfacing the deck. The work will ensure the flyover serves London, with no requirement for major maintenance well into the future. Overall, this intelligent use of technology is driving design efficiencies, eliminating programme and safety risks and speeding up repairs to minimise disruption to the public.

"The application of smart technology on Hammersmith Flyover is delivering significant benefits through design, construction and onwards into operation and management. It has supported a unique collaboration between designer, contractor and client, enabling us to collectively develop the complex, cutting edge solutions that will ensure the safety of the flyover and keep journey times reliable."
Stephen Pottle, Structures Manager, Transport for London



Project Team
Client: Transport for London (TfL)
Designers: Ramboll and Parsons Brinckerhoff
Principal Contractor: Costain

Matthew Collings, Project Director
Ramboll

Steve Denton, Engineering Director
Parsons Brinckerhoff

The successful deployment and integration of a range of digital tools has been at the heart of the design of the strengthening works for Hammersmith Flyover.

Of particularly note were the benefits achieved through the use of laser scanning and the smart post-processing of the results. The flyover has a unique set of constraints and challenges. This form of reality capture proved the most efficient, comprehensive and accurate method of undertaking a complete 3D survey of the structure, particularly given its many inaccessible areas.

Ultimately this rich data provided sufficient confidence to significantly reduce the amount of strengthening required without comprising safety, thereby saving time, money and reducing disruption to the travelling public.

"London's road networks are the arteries and veins that keep the city moving. This is why it's essential to employ the very latest technology to deliver the long-term viability of an asset such as Hammersmith Flyover to support efficient and effective movement into and out of London."
Dana Skelley, Director of Asset Management, Transport for London

Haringey Council Energy Masterplan

Project Status: Strategy development stage, due to complete October 2014

A 5D smart energy masterplanning tool for LB Haringey is contributing to both future sustainable regeneration plans and the design of low carbon energy networks across the borough.

The London Plan actively encourages developers to support and connect with local decentralised energy networks that provide cost-competitive, low-carbon heat and power. Parsons Brinckerhoff has worked with the Borough to develop a quantitative means of identifying where energy demand is greatest, both now and in the future, and the most effective strategies for delivering integrated decentralised energy schemes.

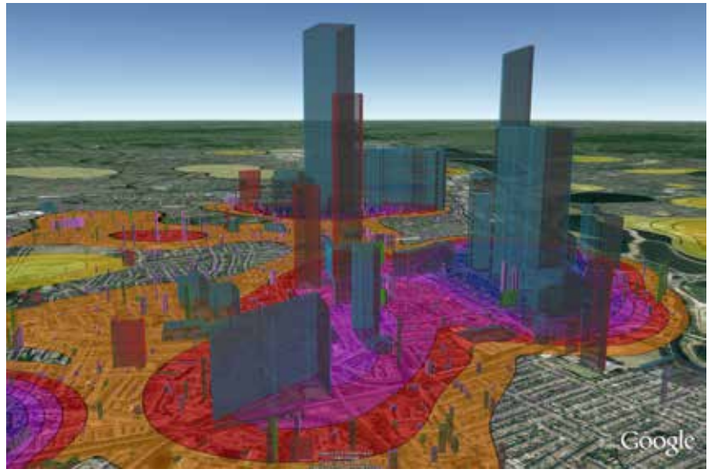
The smart energy masterplanning tool makes innovative use of GIS technology to analyse the geo-spatial inter-relationships between energy demand density, development implementation programmes, physical constraints and cost information. The tool allows users to interact with detailed, evidence based energy masterplans, based on large multi-variant data sets, in a time efficient manner.

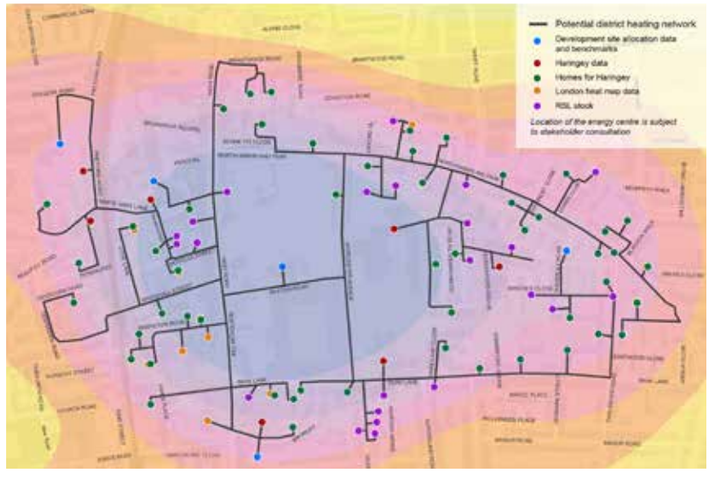
The outputs from the tool are visualised through Google Earth to help all stakeholders easily understand the impact of future development on energy demand and the most effective strategy, on a local level, to connect and deliver energy to identified loads.

The ability to objectively analyse and graphically present complex data assists in the prioritisation and programming of decentralised energy schemes. This provides an evidence base for the development of policy and helps to maximise the potential benefits delivered to communities.

"Our energy masterplan provides the evidence base to support the use of decentralised energy as a means of delivering sustainable regeneration. The Smart Energy Masterplanning tool allows us to visualise complex energy data sets and understand the drivers and opportunities for implementing decentralised energy networks across our borough."
Simone Sullivan, Decentralised Energy Officer, LB Haringey

Project Team
Client: LB Haringey
Energy Masterplanner:
Parsons Brinckerhoff





Developers planning longer-term schemes can work with the borough to see how the shape of the energy network will change as other future schemes come online.

The provision of low cost, low-carbon energy is a significant issue for the borough as it implements a sustainable regeneration vision which includes transforming Tottenham Hale, Wood Green and the Haringey Heartlands. This tool can help developers and the council shape energy supply strategy and support the vision of 21st century urban centres delivering a thriving community and business economy.

"Borough-wide energy masterplans are fundamental in establishing the potential for market competitive area-wide heat networks. The application of smart technology to identify viable heat demand clusters and heat supply arrangements will deliver optimised plant investment and operation and maintenance costs, leading to improved energy efficiency and environmental benefits for London."
Peter North, Senior Manager, GLA

Dominic Bowers,
Director of Energy Solutions
Parsons Brinckerhoff

The volume and quality of energy and related contextual data available to energy masterplanners has grown significantly in the past five years. Whilst this increase in data availability offers the opportunity for a greater insight into the geo-spatial distribution of energy demand there is a risk that the sheer volume of data makes analysis cumbersome, hampering the ability to produce clear, evidence-based energy masterplans.

The Smart Energy Masterplanning tool allows us to analyse large data sets and to visualise technically complex data in a way that makes it accessible to a non-technical audience. With its smart functionality we can work alongside planners and developers to explore a wide range of development scenarios and their impact on the local energy supply mix.

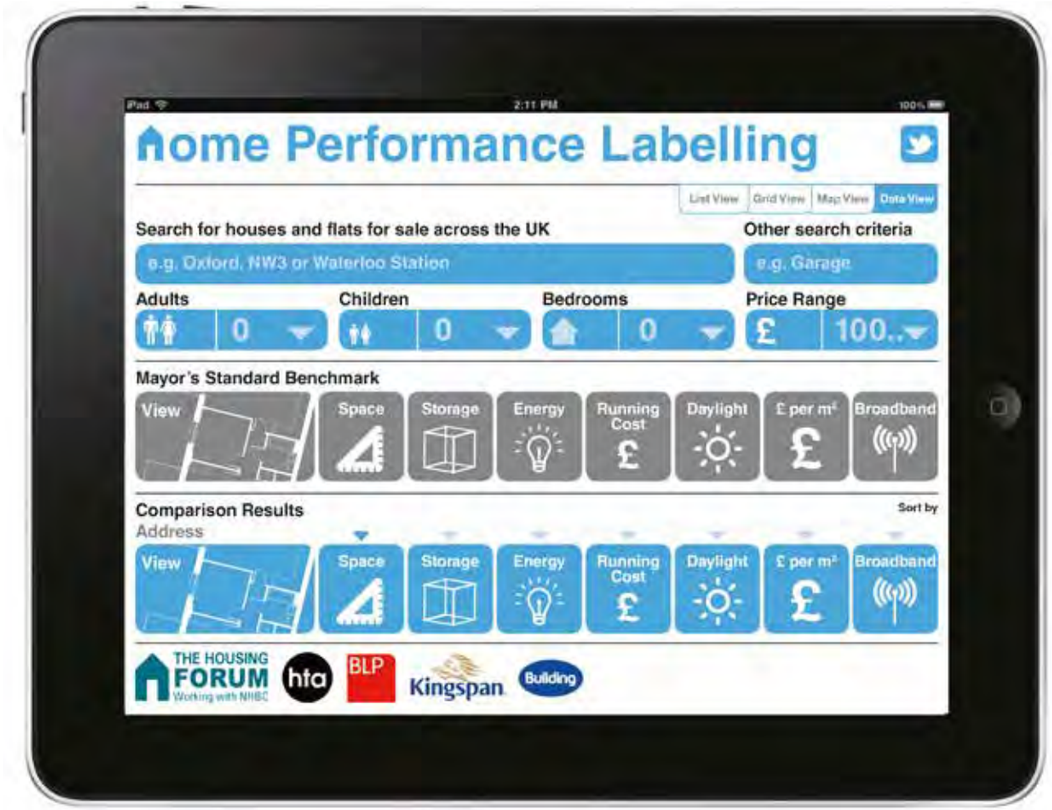
Home Performance Labelling

Address: United Kingdom
Project Status: Pilot project currently underway

The Housing Forum has been advocating improved consumer labelling of new and second hand homes for some years, arguing that awareness of key performance measures is necessary to create consumer pull towards better quality and value in newly built homes and measures to improve the energy performance of existing ones.

Members of the forum are participating in a pilot designed to test the concept that key measures of performance can be readily assessed on the basis of both design information (for the purposes of the pilot, based on BIM) and marketing material. Performance data is presented ranking homes against each other and also against the benchmark of recently established Housing Design Standards (in this case published by The Mayor of London).

Two members of the forum, HTA Design LLP and BLP Insurance, have set up a joint venture to build a fully functioning comparison website. This will be able to match the Housing Forum sample of new and existing homes against the performance expected by the Mayor's Standard and rank them according to the following range of measures: price, net floor area, cost per square meter/foot, storage area, volume, average daylight level, estimated annual energy costs, estimated annual maintenance costs and broadband speed.



The website is designed as a module that can take the information normally presented by housing comparison sites such as Zoopla and RightMove and enhance it by enabling browsers to rank properties offered by the search engine according to their predicted performance. It also presents consumers with a traffic light indicator showing how homes rate in relation to established standards of design. There is no attempt to summarise the ranking with an overall performance – the website design recognises that customers' priorities differ and therefore enables browsers to rank the homes according to their own choice of the most important criteria.

The Housing Forum will be working closely with the Royal Institute of Chartered Surveyors to evaluate the implications of such easily comprehensible information on the valuation of homes. It is hoped and expected that the outcome will demonstrate how valuation can take account of design that enhances performance and meets customers' aspirations for functionality and aesthetic appeal.

Project Team
Web Design & Development: HTA Design LLP
Principal Sponsors: BLP Insurance
Host: Housing Forum
Sponsors: Kingspan
Media Partner: Building

Stephen Hodder, President
RIBA

We welcome this initiative from the Housing Forum, which reflects one of the main goals of our HomeWise campaign for better new homes, which has made the case for a more consumer-oriented housing market and better, more transparent marketing information. We want to see clearer, standardised and benchmarked product labelling provided by all developers and estate agents so that people are able to make more informed decisions when choosing a home.

Product labelling, in addition to robust nationally defined housing standards in areas such as space, energy efficiency and daylighting, would be a big step forward in ensuring we build homes that are built to last and meet the needs of 21st century lifestyles.

Hanham Hall Hub - UK

Building under construction, website active

Hanham Hall is the first site to be delivered under the government's Carbon Challenge initiative and delivers 185 innovative new homes with integrated sustainable living and environmental considerations. The specially commissioned post-occupancy website enables a direct line of communication between residents and the housing management company, as well as within the community itself. Local area information is provided alongside information about the development, and gives residents the opportunity to secure features such as booking the local car club, applying for an allotment or paying the service charge.

Website Design & Development: HTA Design LLP
Client: Barratt Homes
Housing Association: Sovereign HA

Here East

Design stage, due to complete in 2016

This mixed-use development will re-use the former Press and Broadcast Centres on the Queen Elizabeth Olympic Park, providing a campus that combines business, technology, media, education and data in the pursuit of innovation. Smart technologies are being deployed throughout the design and construction processes, including the use of BIM, generative design tools and digitally printed facades. The state-of-the-art data centre and high-speed fibre connectivity will enable the community to be at the forefront of digital technology use, engaging in the buildings and neighbourhood through bespoke digital interfaces.

Client: Delancey & iCity
Architect: Hawkins\Brown
Structural, Fire & Acoustic Engineer, & Access Consultant: Buro Happold
Project Management: Colliers International
Mechanical & Electrical Engineer: Cundall
Cost Consultant: Gardiner & Theobald
Landscape Architect: LDA Design

Hudsons Yards - New York City

Under development, due to complete in 2016

This new 28-acre neighbourhood will be built on a platform above an active rail yard, with trains remaining operational throughout the project's construction. The development will include a wide mix of uses, including office and residential space, as well as retail, cultural venues, a school, and a large provision of public space. It will be a "quantified community", with data tracking pedestrian flows, street traffic, air quality, energy use, waste disposal, recycling, and health and activity levels of workers and residents – aiming to make the neighborhood more efficient and improve the quality of life.

Developer: Related Companies and Oxford Properties Group
Architect: Kohn Pedersen Fox (KPF)
Contractor: Tishman Speyer + Tudor Perini
MEP/FP/IT: Jaros Baum & Bolles
Structure: Thornton Tomasetti
Data Tracking: New York University Center for Urban Science and Progress

Inclusive design hub for the built environment

Initial phase complete, launched July 2014

Design Council has created a new one-stop shop for information and guidance about design in the built environment. This resource integrates information from across the industry – including planning, consultation, design and management – and covers all scales from individual buildings and spaces to city scale and sectors from housing to healthcare. It will continue to grow as an information source, reflecting the latest thinking. The outcome is a community of professionals and clients that are better placed to make informed decisions to help deliver more inclusive environments.

Project Manager: Design Council
Funder: Department of Communities and Local Government (DCLG)

Jeddah Environmental and Social Masterplan - Saudi Arabia

Completed December 2013

Jeddah's rapid growth from historic trading port and gateway to Mecca to a city of over 3.5 million has resulted in a highly complex social, environmental and economic challenge. Inaction poses a significant cost. The masterplan aims to resolve these complexities, taking a 'systems' approach based on drivers, pressures, state and impacts to clearly map out the 'state of environment'. The pathways and linkages within the environment and social conditions were revealed and, when correlated with the outcomes of stakeholder dialogue, enabled planned actions to be targeted to where they will most efficiently deliver changed outcomes and an improved cityscape.

Client: Presidency for Meteorology and Environment, Kingdom of Saudi Arabia
Environmental & Masterplanning Consultancy: Ramboll UK

King's Cross Development Strategy

Under development, due to complete 2017

This two-hectare site has a continuous shared basement linking six buildings, each designed by different architects, and built by numerous contractors over a phased construction period. A strategic set of "Design Rules" were thus developed to enforce a coordinated process, which then linked to a holistic site-wide interactive model. With parts of the foundation construction completed before some building design was finalised, this process became critical in ensuring all the parts of the development jig-saw fitted together.

Client: King's Cross Central Ltd Partnership, BNP Paribas Real Estate UK
Architects: Allies and Morrison, David Chiperfield Architects, Porphyrios Associates, Eric Parry Architects, Bennetts Associates, LA Architects, Wilmotte UK, Adamson Associates, Weedon Partnership
Structural Engineer: AKT II
Cost Consultants: AECOM, Gardiner & Theobald, Gleeds
M&E Consultants: Grontmij, Hoare Lea
Contractors: Bam Nuttall, Bam Construction, Kier, Vinci

King's Cross Station

Completed January 2013

Microstation's technology – providing an information modelling environment – enabled the successful reorganisation of the station and coordination of this with enhancements to the platform operation, whilst rail services continued undisrupted. This couldn't have been possible without the ability to digitally represent the project in its entirety; specifically by speeding up the design process and accurately predicting the outcome of works to the existing historical fabric. It improved efficiency through the reduction of errors in documentation and also by allowing rapid communication of the design to the client, consultative organisations and project collaborators.

Client & Cost Consultant: Network Rail
Architect & Masterplanner: John McAslan + Partners
Engineer (western range & concourse): Arup
Main Contractor: Laing O'Rourke Costain JV
Contractors: Vinci Construction UK, Kier Rail, Osborne, Carillion

Land Insight

Under development, due to complete November 2014

Land Insight is a web application that makes it easier to uncover hidden building opportunities by using big data to allow a super-fast initial site assessment on any piece of land. On top of this massive dataset is a crowd sourced insight layer that creates an ever-improving list of opportunities and collaborations not to be found on the open market. The platform is currently being road tested by East London Custom Build Group.

Developer & Designer: Land Technologies

MOLA GIS

Address: Greater London
Project Status: Evolving resource

London has developed over centuries, rising upwards with successive layers of building and rebuilding, and outwards, as the city expands, absorbing the villages and towns in its hinterland. MOLA (Museum of London Archaeology) has been excavating, studying and documenting the physical remains of London past since the early 1970s. Twenty years ago they started compiling all of their information and results into a single digital framework, to keep track of the multitude of data coming in and to allow patterns of development to be analysed in a way that simply could not be done with analogue systems.

Diverse mapping information and metadata is added to the MOLA GIS, including street layouts dating back to the Roman period, major historic properties, lost burial grounds, and importantly areas of past archaeological investigation, including details of the extent of previously excavated trenches. The archaeological features from all of the excavations MOLA has conducted since the early 1990s have been digitised and geo-referenced and the artefacts found within them located within the GIS through an Oracle database.

Today the MOLA GIS is a unique and constantly developing resource. It brings together information on the underlying geology and topography of London, pinpoints areas of archaeological potential, details the development of settlements, industry, trade and infrastructure and provides evidence of changing social circumstances; wealth, poverty and disease.

"What is really smart about the MOLA GIS is that it is always developing. Within the masses of structured data are the clues to what has made London the great city we know today"

In practice: Starting at the deepest levels, the team at MOLA work in partnership with geotechnical engineers in the early stages of a project. Sharing information from historic boreholes, Site Investigation works and geoarchaeological augerholes, they build up records of the surface geology beneath London. The data is held in a standard borehole database (RockWorks) typically used in the environmental, geotechnical, petroleum and mining industries. It is then migrated to and manipulated within the MOLA GIS 'world' to give a picture of the topography as it was in the past, prior to burial beneath successive layers, including Thames River deposits, debris built up in the medieval period and modern man-made accumulations.

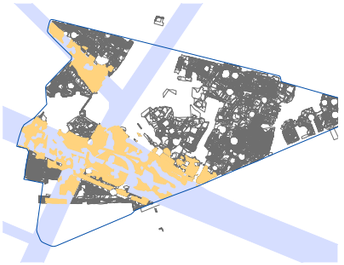
Its applications: This GIS has several functions and benefits. Topographic models can be relied upon by developers during site acquisition and throughout the planning stage process as a tool to predict areas of higher and lower archaeological potential. 'Lost' burial grounds and information on deeper and more complex archaeological survival are vital details that it pays to understand early in the development process. Should archaeological investigation follow, the GIS can inform targeted archaeological programmes.

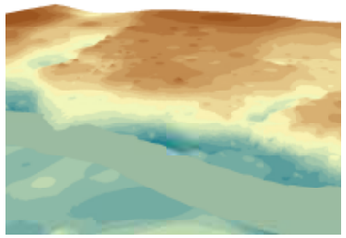
Moreover, as an evolving model of London through time and space, it is particularly useful as a tool for understanding wider landscapes within development zones across the city. The benefit of taking a wider look is that it enables more accurate interpretations of past landscapes to be made, which in turn helps to refine archaeological strategies.

The MOLA GIS is a tool for developers but also for researchers; answering complex questions about the distribution of goods, industries and people in the past. What is really smart about the MOLA GIS is that it is always developing. Within the masses of structured data are the clues to what has made London the great city we know today.

"Lost burial grounds and information on deeper and more complex archaeological survival are vital details that it pays to understand early in the development process."

Project Team
Developer: MOLA
Consultants: Geotechnical Consulting Group, Institute of Historical Research, University of London





Jackie Skipper, Geotechnical Consulting Group
RIBA

Geotechnical Consulting Group worked with MOLA on a very complex job in the City of London. During the project engineering site investigation it emerged that ground conditions at depth were far more complex than anticipated, and may be related to the surface geology. Collaborating with the MOLA archaeologists and geoarchaeologists was extremely helpful and the geotechnical side of the project gained immensely from applying a more synergistic approach to analysing the stratigraphy of the surface deposits. We learned much by seeing how MOLA collected their data and managed it within a wider area deposit model, and in the end both parties gained from the expanded understanding of the geology and archaeology. The unique insight from this collaboration is planned to result in a scientific paper which will contribute to the understanding of the engineering effects of these isolated but important ground conditions.

Project Croydon – Programme Delivery Dashboard

Status: On-going, due for Cabinet approval in September 2014

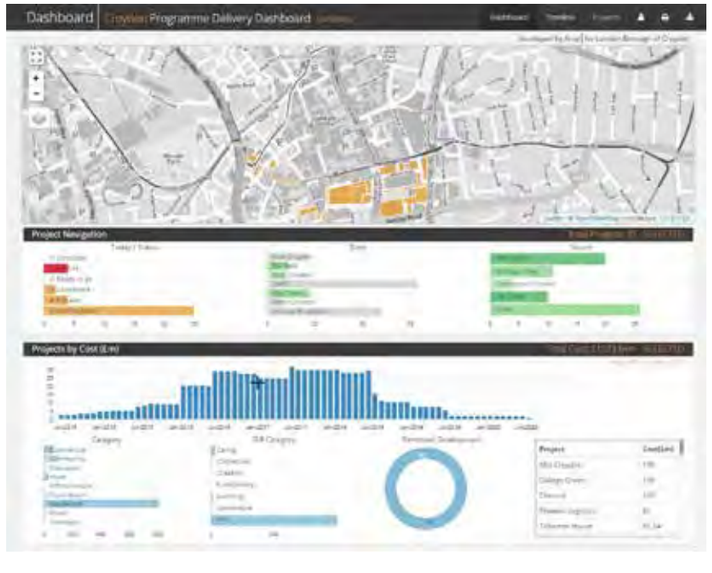
The London Borough of Croydon (LBC) is on the cusp of an unprecedented period of regeneration. In the next five years, over £3 billion will be invested in the city centre, with the aim of transforming the district as a place to live, work and visit. This regeneration programme is being led by the Croydon Partnership – a £1 billion Westfield/ Hammerson scheme – with the aim of the centre of Croydon becoming Europe's largest urban retail/leisure destination. Through the regeneration programme, 21 major schemes related to the city centre and numerous smaller projects will be brought forward, delivering approximately 3,000 new homes, up to 2.8 million square feet of new commercial space, 2 million square feet of new retail/ leisure facilities, seven new hotels, 28 new public spaces and places, and new education facilities.

However, unlike other comparable major regeneration initiatives such as Nine Elms, the Olympic Park and King's Cross, the Croydon regeneration programme needs to be managed on a live site, and keeping one of London's busiest urban centres active, vibrant and vital. To enable the regeneration programme, LBC brought in Arup to design a five year integrated delivery plan. The plan will define how multiple regeneration sites can be developed efficiently, effectively and in an integrated manner, whilst maintaining the fabric of the site as a working and living city centre.

To support the implementation of the Five Year Integrated Delivery Plan for Croydon, Arup developed an analytical tool to capture and predict the impact of any changes within the regeneration programme. Arup's innovative Programme Delivery Dashboard is intended to: 1) assist with the data capture of the 167 separate projects which make up this programme; 2) facilitate categorisation and integration of the project data avoiding unnecessary complication; and 3) allow intuitive and easy interrogation, from which conclusions and recommendations could be made.

The Dashboard is a web-based interface linking to a project information database including spatial mapping data. Arup developed the Dashboard from the ground up, using open source code and database programs. It is currently hosted by Arup, on an external facing server

Project Team
Client: London Borough of Croydon
Developer & Project Manager: Arup



with password protection, with many key stakeholders including TfL, GLA, EC Harris, URS, TTR and Shared Intelligence already accessing the platform.

When developing the Dashboard, workshops were held with LBC and key stakeholders to validate data and to shape its design and functionality. The Dashboard quickly became referred to as an "on-going tool" rather than simply a reporting mechanism to inform the integrated delivery plan. Today the Dashboard plays a key role on the Programme, including:

- Providing an intelligent, interactive 'single point of truth' for the 167 projects in the programme
- Enabling real time, intuitive interrogation of programme information
- Identifying cumulative impacts and common priorities across projects
- Accommodating updates and changes to the programme
- Facilitating communication in the programme by sharing and making information transparent

The intention is that now the five year integrated delivery plan has been delivered, the Dashboard will continue to be used by LBC regeneration managers and all key stakeholders to manage the impact of and improve efficiency with the delivery of all the separate development sites & projects in the Croydon Opportunity Area. The dashboard has already significantly improved day to day tracking, reporting and operational analysis of the Programme, but, more importantly, it is allowing clear strategic forward planning and prioritisation of developments over the next five to ten years.

Arup and LBC are planning further enhancements to the dashboard, ranging from a public way-finding service, to a pollution data mapping service, to a fully integrated 3D city model.

Jo Negrini, Executive Director
Development & Environment at LBC

The complexity of delivering one of Europe's biggest regeneration programme whilst maintaining and enhancing the day to day operation of south London's largest urban district is an enormous and exciting challenge. To achieve all our aspirations for Croydon, we developed our Integrated Delivery Plan to identify a clear set of milestones and the 169 schemes key schemes, with a value of over £5bn, that need to come forward in the next five years. Developing the Programme Delivery dashboard has been critical in understanding the combined impact of these schemes, identifying and mitigating any stress points, and providing an on-going, live mechanism to ensure the council is confident and capable of maintaining the highest quality services for all those that live, work, invest in and visit Croydon during this unprecedented period of transformation. The Five Year Delivery Plan and its Dashboard form a powerful mechanism for driving delivery and change in the Croydon Metropolitan Area.

"The dashboard looks very impressive with the potential to become a very useful tool for stakeholders… we think it looks amazing"
Tim Rettler, Principal Project Officer, GLA

"The dashboard is visually excellent and intuitive to use."
Steve Yewman, Development Director, Westfield

Rathbone Square

Address: 35-50 Rathbone Place, London W1
Project Status: Under development, due to complete January 2017

Rathbone Square is a mixed-use development comprising commercial office space, private and affordable residential apartments and ground floor retail accommodation totalling 414,000 square feet. The proposals will provide a major new public space in the form of a landscaped garden together with pedestrian routes linking Rathbone Place and Newman Street.

The new development comprises two orthogonally-aligned 'L' shaped blocks arranged in a 'pin wheel' configuration around a large, landscaped garden. Comprising six to eight floors plus three basement levels, the blocks are split into two uses; the offices are located along the south side of the site close to Oxford Street, while the residential block is located to the north and west near the quieter Fitzrovia neighbourhood. All parking and loading bays are concealed within the building to free up the street level for pedestrian use.

An orthogonal grid enables multiple layouts and configurations within a unifying framework, which is seamlessly integrated with the surrounding streets and squares which were laid out in the eighteenth century. The composition of the new buildings responds to the scale, character and aesthetic of Fitzrovia and complements the area's diverse architectural expression.

The design team has embraced a new methodology of 'collaborative modelling', utilising BIM software tools to produce a 'co-authored' three-dimensional model which is central to the design, procurement construction and maintenance of the project.

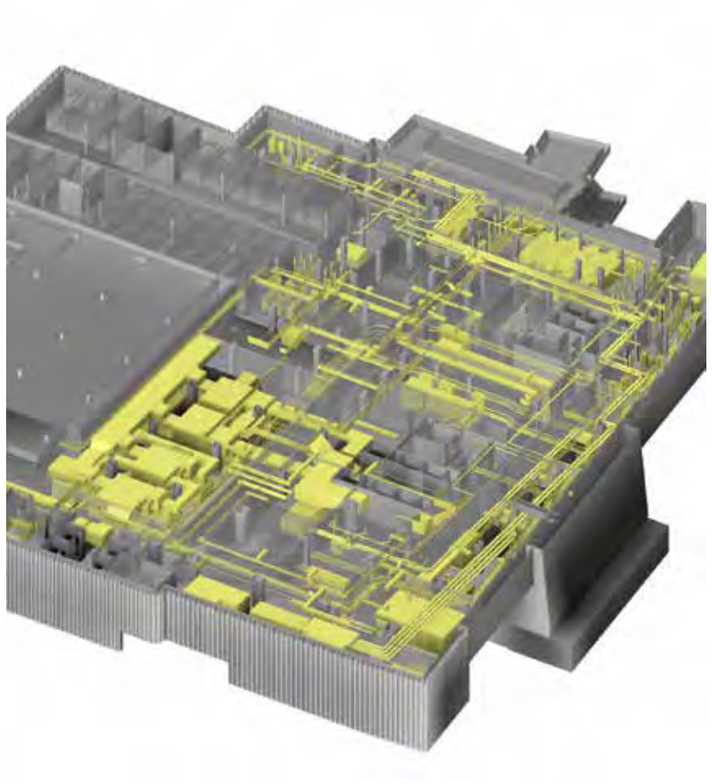
This approach has allowed seamless multi-disciplinary collaboration. For example, the model has been used to develop the public space design. The building mass has been carefully considered through iterative computer models and simulations enabling almost every part of the space to receive direct sunlight in the summer months. Pedestrian flow and wind analysis have also utilised the model contributing to the resolution of the space and garden design. The facade has also been developed utilising the model; a balance of solid and glazed areas of facade were 'tuned' through numerous geometric and technical simulations to provide high levels of insulation, while ensuring good levels of daylight and reduced solar gain.

Virtual reality headsets and computer-generated animations provide an immersive experience which have been used alongside traditional visualisation techniques, physical models and full-scale mock-ups to develop and communicate the design proposals. The model is also being used by the contractor to develop complex work sequences, programmes and to simulate 'virtual practice sessions' to rehearse intricate or potentially hazardous parts of the build. The model has been utilised to construct a residential prototype apartment, the build of which is being documented for film to brief trades and understand the work sequence.

The computer model will be developed by the trade contractors and will contribute to commissioning and completion. The 'as built' computer model will be delivered to the client upon completion to assist in the operation and maintenance of the built asset.

"GPE's constant search for innovation and improvement in productivity are driven by our desire to deliver high quality architecture and construction to our occupiers and the general public. Rather than invest in design and technology just for the sake of it, we try and understand what benefit it will bring to the process in terms of production and installation. To be successfully implemented, we need buy in from the entire project team and for that to happen we have to keep the steps in smart technology as simple as we can. As a result, we have received buy in throughout the supply chain and look forward to seeing the results delivered over the next couple of years."
James Pellatt, Head of Projects, Great Portland Estates

Project Team
Client: Great Portland Estates
Project Manager: Buro Four Project Services Ltd
Architect: Make
Planning Consultant: Gerald Eve
Landscape Architect: Gustafson Porter
Structural Engineer: AKT II
Building Services Engineer & Sustainability: Hilson Moran
Fire Engineering Consultant: Jeremy Gardner Associates Limited
Transportation And Waste Management Consultant: Steer Davies Gleave
Facade Consultant: F+M Design Consultancy
Facade Access: Hilson Moran
Cost Consultant: EC Harris LLP
Party Wall And Rights To Light Consultant: Gordon Ingram Associates
Visualisation: Miller Hare
BIM Consultant: BIM Technologies
Access Consultant: Access=Design
Lighting Consultant: Spiers and Major
Office Planning: KKS Strategy



"Napoleon Bonaparte is reputed to have said to one of his generals that, 'Imagination rules the world.' Some might say that only Napoleon's imagination could stretch as far as world domination, but I think he might have been on to something. The danger for us as architects designing in the modern world is to fall into the trap of allowing smart technologies, software, protocols or procedures to dictate design. I'm certain that if Wren was practicing architecture today he would have been a BIM enthusiast, but I'm also sure that he would have continued to 'strive for eternity' in his architecture. A beautiful building designed using an ink pot and quill is still more desirable to an ugly one designed on a computer."
Graham Longman, Make Architects

Graham Longman, Lead Architect
Make Architects

It is very easy to be seduced into relying on high-tech tools when designing complicated buildings. The computer is undoubtedly an amazing machine that has changed the way we work as designers. However, we have learnt that it is important to use the 'right tool for the job'. In fact, in most instances during the course of designing Rathbone Square we have used a combination of high-tech and low-tech tools. Sketch models made from pieces of foam board, card, plastic and glue have been used to test design ideas, whilst at the same time computer models have also been used to generate full scale, CNC cut, foam mock-ups. Tracing paper, colouring pencils and sketchbooks have been used alongside complicated collaborative computer models, laser-cut modelling techniques and augmented reality devices.

Loadsensing

In use, permanent improvement works being carried out

Loadsensing is a wireless system that allows the monitoring of large structures, with the aim to detect and prevent possible risks and to ensure an optimal use. The system collects data from a wireless sensors network and sends it to a database, triggering alarms when necessary. It was installed to monitor the Olympic Arena Palau Sant Jordi, in Barcelona. The solution allowed engineers to know in real time the weight and stress supported by every beam, so every event can be developed optimally without being exposed to any risk. The solution is also being used to monitor buildings, bridges, tunnels and loading harbours.

Developer & Designer:
Worldsensing

Locating London's Past

Completed in 2011

Locating London's Past is an interactive website which allows users to search the locations of crimes as recorded at the Old Bailey between 1674 and 1913. MOLA provided spatial data, manipulated digital images and related historic maps to the modern landscape, creating a seamless map. The Locating London's Past website is widely used by historical researchers and won the 2014 British Society for Eighteenth-Century Studies' (BSECS) Prize for Digital Resources.

Funder: Jisc (Joint Information Services Committee)

Project Leaders: University of Sheffield, University of Hertfordshire, Institute of Historical Research, University of London, MOLA

New London Development

In use, launched March 2013

In association with Estates Gazette and supported by Deloitte Real Estate and the Mayor of London, this NLA developed interactive map outlines development activity across the capital. The website currently features over 800 projects, acting as a resource for viewing all major developments in London. It features recently completed projects through to proposed future developments, and gives the ability to filter the status of the building, sector and area. Users can see overlays for future transport routes, identify development activity within each borough, and see showcases of developer's portfolios. The website can be accessed via all mobile devices and is also available as an iPad app entitled 'New London' via the iTunes store.

Developers: NLA & Pipers Design
Collaborators: NLA, Estates Gazette & Deloitte Real Estate
Supporter: Mayor of London

Mayfield School

Under construction, due to complete December 2014

To deliver a highly sustainable 8,500sqm school in just 18 months, David Miller Architects is combining BIM's ability to manage complex information with Cross Laminated Timber's (CLT) suitability for off-site mass customisation. Through cloud-based collaboration between the design team and the supply chain, a virtual prototype of the building was used to analyse and perfect the design before construction. The construction method reduces carbon emissions by 50 per cent compared to conventional techniques. The model can later be used for facilities management, further enhancing energy efficiency.

Client: LB Redbridge
Architect: David Miller Architects
Structural & Services Engineer: Ramboll UK

CLT Sub-Contractor: KLH
Contractor: Bouygues UK
Services Sub Contractor Engineer: LJJ Ltd

Milton Keynes' Wireless Electric Buses

Completed January 2014

The cost and logistics involved in running electric buses have prevented them from becoming mainstream in urban environments, however, this five-year demonstration pilot has brought wireless charging technology to power a fleet of eight electric buses in Milton Keynes. The technology enables the electric buses to run non-stop throughout the working day – up to 17 hours a day, seven days week – with a significantly lower carbon footprint than their diesel counterparts. The buses draw power wirelessly from 120kW charger plates embedded in the road at either end of the 15-mile route. The pilot enables all parties involved to examine how the new technology performs in a real-world setting.

Project Manager: MASP (JV between Mitsui and Arup)
Transportation Consultants: Arriva, Wrightbus

Energy Consultants: Chargemaster, Conductix-Wampfler, SSE
Local Authority: Milton Keynes Council

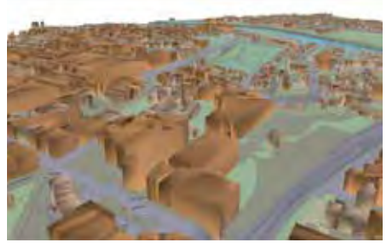
North West Bicester

Phase 1 under development, due to complete Summer 2015

Providing up to 6,000 sustainable new homes in Bicester, Oxfordshire, and home to the UK's first true zero carbon community, this project will be a net provider of energy, creating more energy than it uses, and aims to be the most advanced eco development of its size in the country. It will encompass a primary school, community centre, district heating plant, eco pub and business centre. The development will incorporate cutting edge technology, economic opportunities and community engagement, with environmental integrity at its core.

Client: A2 Dominion
Masterplanner: Farrells
Sustainability Integrator: BioRegional

Technical Consultant: Hyder
Employment Specialist: SQW
Planning Consultant: Barton Wilmore



Ordnance Survey 3D data

In use, completed August 2014

Ordnance Survey (OS) are working with partners to provide 3D height data solutions for construction professionals, with the aim of revolutionising and underpinning planning visualisation and impact analysis. This will have the potential to feed into BIM workflows. Landmark Information Group have launched a 3D Data Bundle, combining OS MasterMap detailed mapping, OS Terrain 5 height data and OS Building Height Attribute information. This 3D representation of the natural and built environment provides easy access to data for visualisation and analysis to enable smarter decision-making, and is suitable for use with 3D printers.

Data Provider:
Ordnance Survey
Solution Provider:
Landmark Information Group

PLACE Network with Virtual Urban Room

Design stage

A key recommendation of the Farrell Review of Architecture and the Built Environment was to have an 'urban room' in every town and city, either as a physical or virtual resource. Virtual urban rooms have since been proposed by Assembly Studios, building on the success of the established Creative Assembly network – an online tool to connect creative, cultural and arts businesses and individuals. This cloud-based network will be capable of connecting all aspects of PLACE (Planning, Landscape, Architecture, Conservation and Engineering) whilst harnessing the power of virtual reality.

Client: Department of Culture Media and Sport
Project Leader: Farrells

Sensing City – increasing resilience

Address: Christchurch, New Zealand
Project Status: Started in 2012, ongoing

Following the earthquakes of 2010-11, the city administration of Christchurch, New Zealand, was faced with a huge task of physically rebuilding the city. With the support of Arup, the Sensing City Trust was established to collect and manage a range of data sets to assist the city's recovery and to stimulate an information-based economy. Recognising an opportunity to rethink how the city of Christchurch could work in the future, Sensing City explores how open data can be used to improve urban living.

Sensing City's first project was to examine the extent of water pollution in the city's waterways following the earthquake damage and on-going reconstruction works. Arup, the Massachusetts Institute of Technology (MIT), Little Device Group and a national fuel provider, Z Energy, collaborated on the project to provide citizens with 'little water sensors'. These sensors allow citizens to test the quality of water around their city and then upload their results via a mobile phone app to inform the city authorities. This first sensing initiative enabled Christchurch's citizens to provide and access information about water quality along the city's main waterways.

While many city governments, like Christchurch, recognise that sensing technology can provide valuable insights, they are uncertain over how to use the technology and the large amounts of generated data to inform their decision-making. Arup advises public and private organisations around the world on how cities can harness their data to improve operations and create valuable services that benefit citizens.

Project Team
End Client: Sensing City Trust
Key Stakeholders: Christchurch City Council (CCC), Canterbury Earthquake Recovery Authority (CERA)
Industry Partner: Infratil
Branding Partner: Strategy

Project Partners / Sponsors: Z-Energy, Canterbury District Health Board (CDHB), University of Canterbury (UC), Massachusetts Institute of Technology (MIT), Callaghan Innovation, Spark Digital

Arup's work is based on the premise that for data to be useful to a city, the underlying digital infrastructure should be open and flexible and should relate to the city's capabilities and objectives. For Christchurch this meant creating a self-sustaining organisation that works alongside the city council and partners with organisations to provide public access to city-wide data and to develop local technical capabilities.

The increasing use of sensing solutions in the built environment is making more urban datasets available in real time, helping cities to promote efficiency and safety, and reducing uncertainty. The Sensing City initiative in Christchurch demonstrates how working with citizens and industry on sensing based solutions can help to manage urban living and address multiple urban challenges.

"Sensing City is an extraordinary global opportunity to be able to better understand how cities really work, and to use that knowledge to meet some of the urbanisation challenges of the 21st century".
Hon Gerry Brownlee, Minister for Canterbury Earthquake Recovery

St James's Market – Building Information Modelling & Augmented Reality

Address line: St James's Market, London SW1
Project Status: In use

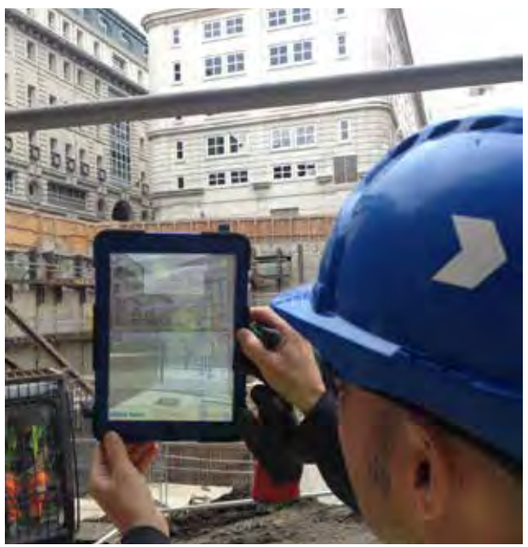
The Crown Estate encourages the use of emerging technologies from project conception, through construction, to deliver a smarter development in a smarter way. St James's Market, in the heart of London's West End, is one of the most high profile and ambitious projects by The Crown Estate to date. The project team has strived to push the boundaries of available technologies.

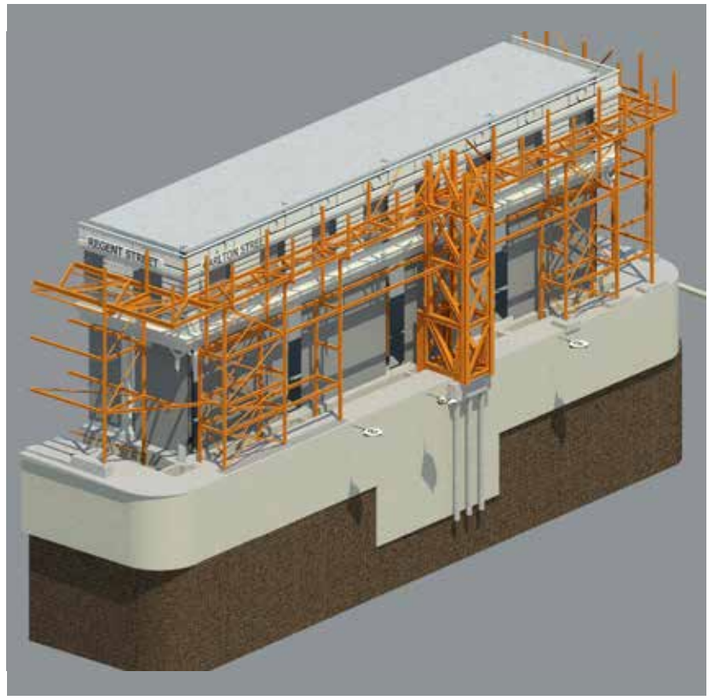
Pre-Construction Phase: From the outset, the BIM was used to plan, review and manage the build of this prestigious development. Balfour Beatty used extensive clash detection and coordination to ensure all services were fully aligned. By the use of 4D (BIM programmed in 3D) and in particular in modelling all temporary works, it allowed for different scenarios and building sequences to be run in a virtual environment, leading to the optimum construction sequence.

Construction Phase: During construction the key priories have been maintaining safety and keeping to programme. BIM and other technologies have been used by all team members from monthly client reviews to daily safety briefings to help deliver these priorities. The project is delivered through a LEAN process and all aspects of logistics and progress are reviewed in 4D within the BIM. The 4D model is then reviewed in both the daily activity briefings to review safety methods and also to review weekly and monthly progress. This information can then be shared with all key team members through the use of tablets and iPads. The use of augmented reality 4D sequencing has allowed site managers in the field to review the future sequence of the construction overlaid in augmented reality with the actual current state of the build.

Operational Phase: The original specification for handover from Balfour Beatty was to deliver BIM in accordance with PAS 1192:2 2013, a standard accepted format compatible with AIM (Asset information Model). During the construction stage, Balfour Beatty came up with several alternative methods of how the BIM data could be handed over in a more readily accessible format. This led to the creation of a new, mobile platform that gives easy access to all BIM data, with no need for training or the need for specialist CAD/BIM software. It provides a visual bridge between all management systems and allows users to virtually or physically walk into any room and access all relevant information about any building asset. Included is a virtual reality feature that allows users to see assets located behind walls or in the ceiling.

"St James's Market is a truly exciting project to be involved with and delivering two major buildings in the heart of London with the largest retained facade in Europe was always going to be challenging, interesting and rewarding. I have been lucky to have the full support of Balfour Beatty and the client to push the boundaries of current technology on the project, which has enabled us to pioneer new technological advancements in construction".
Johnny Furlong, Information Manager, Balfour Beatty





Project Team
Client: The Crown Estate
Development Partner: Oxford Properties
Development Manager: Hanover Cube
Main Contractor: Balfour Beatty

Alastair Smart, Head of Development and Project Management
The Crown Estate

The world of development is constantly evolving, and we are always looking to find new and ever more efficient ways of delivering excellence. Technology plays a big part in this for The Crown Estate, and we work closely with our supply chain to push the boundaries and explore new and emerging technologies.

We have used BIM technology to deliver our developments at Quadrant 3, St James's Gateway and Block W4 on Regent Street. We are committed to ensuring that the lessons learned are progressed from project to project so that we can ultimately pass the benefits on to our customers on completion.

One of the largest and most impressive sites in our current development pipeline is the St James's Market site, and our main contractor Balfour Beatty has really responded to our vision in their use of technology to help deliver on a challenging and high profile central London site.

Strand Campus, King's College London

Project Status: Design stage, due to complete in 2019

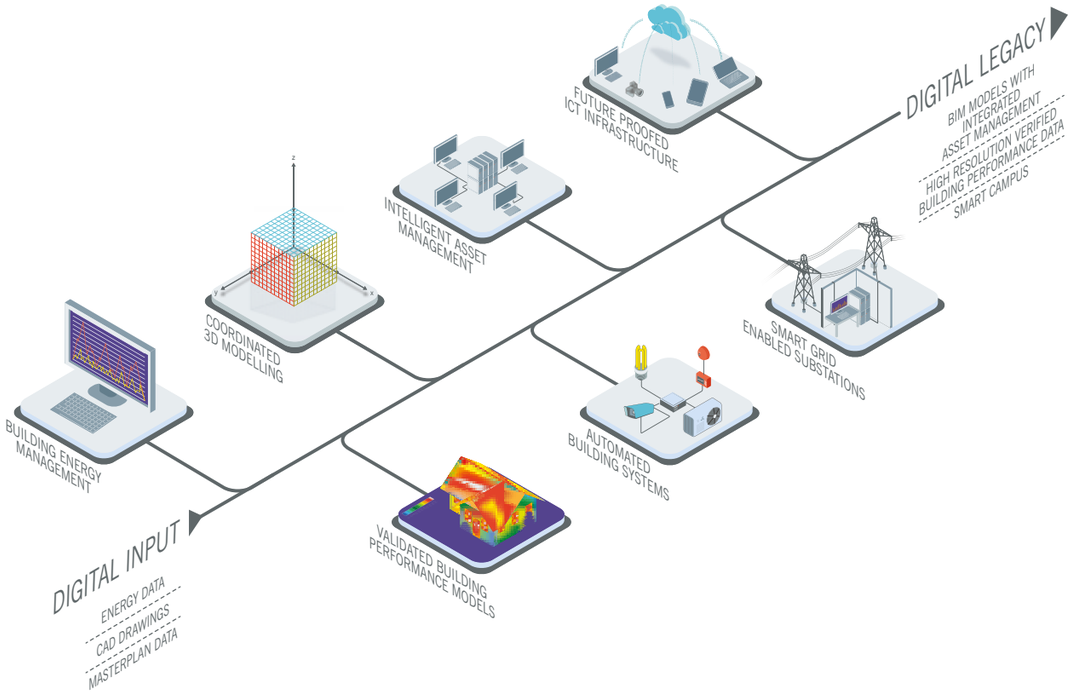
King's College London has produced a masterplan for the redevelopment of its Central London Strand Campus to allow growth in both academic departments and student numbers. Phased across a number of projects over a 10-year period, the masterplan seeks to improve the quality and flexibility of academic space whilst reducing operational CO_2 emissions. The masterplan will also ensure increased connectivity within the campus and enhance the external public identity of the buildings.

These objectives need to be delivered against a backdrop of a physically constrained, heterogeneous, listed campus that needs to continue teaching, research and commercial operations throughout the development programme. Parsons Brinckerhoff has been appointed by King's College as the Mechanical, Electrical and Public Health systems masterplanner for the Strand Campus, with the aim of developing engineering strategies and technical standards that, when implemented, will help to deliver best practice engineering across the campus. The development of a digital technology strategy will deliver improved integration, efficiency and utilisation of the campus. This strategy will help to achieve the campus masterplan objectives by ensuring that the separate development projects, when complete, deliver an integrated, flexible, smart campus.

Using digital technology to analyse energy demand and building system operation is a vital step towards implementing a smarter Strand Campus. To realise this potential, King's adopted the Demand Logic web system. This cutting edge technology uses data analytics and infographics to find energy savings and performance improvements in the campus buildings. This system has identified over £390,000 in savings since January 2013.

"This role is key to delivering our carbon management plan which the College takes seriously, and will help resolve historic infrastructure and backlog maintenance issues. While primarily focused on the Strand, our key learning will support our other campuses as well."
Nick O'Donnell, Director of Real Estate Management, King's College London

"The Demand Logic web system allows us to see at a glance where problems are likely to be. Without this, it's like trying to find a needle in a haystack"
Ian Armitage, Campus Operations Manager, King's College London



Parsons Brinckerhoff is working closely with the College and project design teams to identify additional means by which digital technology – including intelligent building management systems, access and control systems, smart-grid enabled electrical networks and future proofed resilient ICT infrastructure – can be integrated across the campus. Another key benefit will be to embed the use of BIM in the design, construction and operation of the redevelopment.

A smarter Strand Campus will deliver wide ranging economic, environmental and social benefits to the College. Specifically, it will help to improve energy and CO_2 management, space utilisation and the quality of academic space. King's is using the redevelopment as an opportunity to capture the digital potential of the campus, helping them to enhance their position as a leading university in a world-leading city.

Project Team
Client: King's College London
MEP Services Masterplanner: Parsons Brinckerhoff
Energy Data Analytics: Demand Logic

Rupert Green, Smart Design Lead
Parsons Brinckerhoff

The systems masterplanning team is using digital technology to address the interdependent technical, environmental and regulatory challenges that are inherent to the complex and historically significant Strand Campus.

The potential to use smart grid technology within the campus provides an opportunity for the College to address their concerns about electrical supply resilience and reliability. A smart-grid will help them actively manage demand across the campus, monitor the operation of critical supply infrastructure and maximise the value of on-site generation.

The use of intelligent Building Management Systems, supported by a future proofed ICT backbone and the Demand Logic web system, will allow building systems to respond automatically to signals from room sensors, HVAC plant and energy tariffs. Integrating the building management, room booking and access control systems allows predictive and reactive response to room occupancy patterns. This integrated approach will allow King's to better manage building energy use and reduce their CO_2 emissions.

Integrating BIM models with the College's asset management system has been identified as a key tool that can help King's move towards being able to actively manage and maintain their assets, improving the resilience, quality and flexibility of their teaching and research environment.

Regent's Place Masterplan

Completed 2013

The Regent's Place masterplan has transformed a disconnected commercial enclave into a network of high quality spaces and streets and an integrated part of central London. A programme of targeted and open community engagement was conducted to inform the masterplan. Energy use is controlled in buildings through integrated electronic management software, which enables the building's energy consumption to be monitored on an hourly basis and the building systems and plant to be controlled for maximum possible energy efficiency.

Client: British Land
Masterplanner: Farrells

Responsive Street Furniture

Under development, due to complete January 2015

The suite of Responsive Street Furniture has been developed in order to bring a flexible and affordable platform for the delivery of smart information to every urban area. Each element has been developed from standard products and hopes to offer a fully coordinated approach to a project. Individual items of furniture may be customised to engage in several different ways, depending on their required response to a user's specific needs. Responses such as adjusting light levels and the playing of audio clips can be tailored and combined to reflect a single user's or diverse group's requirements.

Developer: Marshalls

Shoreditch Digital Canvas

Design stage, due to complete in 2015

The Shoreditch Digital Canvas is a vision to create two vibrant digital art and advertising installations of a unique and site-specific quality that will be located around the Shoreditch Triangle area. Re-appropriating two vacant unattractive spaces and regenerating these to provide a platform for digital artists and for digital advertisers, each site will contain an arrangement of digital LED displays acting as a canvas for use by advertisers, artists and the community alike. The aim is to create a unique platform to encourage artistic and creative use rather than standard format advertising.

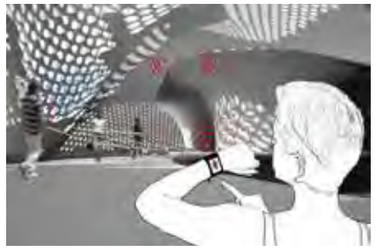
Design: Jason Bruges Studio
Consultant: Wildstone
Local Authority: LB Hackney

Siemens Middle East Headquarters

Completed January 2014

Merging parametric technology and traditional design ideas, this 22,800sqm structure is truly optimised for purpose, delivering the most sustainable building possible for the same cost per square metre as a typical headquarters in the UAE. Utilising computerised parametric software at design stage, the efficient and compact form uses less material and has minimised embodied carbon. The shape, size and positioning of the solar shading was determined by a computer algorithm – helping find the precise solution for allowing no direct sunlight to hit windows whilst allowing the maximum amount of daylight into the interior. This passive strategy for controlling solar gain in an extreme climate is just one example of how a technological process helped find the right low-tech solution.

Client: ADFEC (Masdar)
Architect: Sheppard Robson
Structural Engineer, MEP & Cost Consultant: AECOM
Project Manager: Morganti
Main Contractor: Al Fara'a General Contracting Company



Smart University Concept

Under development

HLM have developed a prototype for a 'Smart University' that specifically makes use of the new opportunities offered by wireless smart controls and wearable technology – which can, for example, collect information on skin moisture and temperature – to reduce energy, whilst providing optimal thermal comfort. The project will make use of big data and visual analytics to monitor and analyse in real-time data from sensors, university systems and weather to enhance adaptive opportunities. A real-time energy-awareness app for two-way communication exchange between building users and the Building Automation System will also be developed.

Architect & Environmental Consultant: HLM
Research & Development Consultants: West London University, University of Manchester, Universität Hannover, BlueMark Innovations, University of Twente

Songdo International Business District (IBD)

Completed in 2011

This free trade and special economic zone, occupies over 1,500 acres of reclaimed land on the west coast of Incheon, South Korea. Designed as a hub for north-eastern Asian commerce, Songdo IBD's density and variety of land use supports efficient buildings, multiple public transportation systems, and centralised systems for municipal infrastructure, including a city-wide pneumatic waste system. Many residential units are computer-controlled, allowing residents to regulate apartments' lighting, heating, cooling and other systems remotely. Wired for large capabilities by Cisco, Songdo's infrastructure and technological capabilities are flexible and can adapt to inevitable technological changes.

Client: NSIC (Gale International and POSCO E&C JV)
Masterplanner: Kohn Pedersen Fox (KPF)
Associate Architect: Kunwon
Engineer: Arup
Landscape Architect: Towers/Golde
Contractor: POSCO E&C

St Alphage Tower

Completed in 2013

Prior to a new Brookfield development, the entirity of the St Alphage Tower monument was laser-scanned using a Leica ScanStation C10. The data collected was merged to create a single 3D point-cloud model of the structure, enabling the creation of models to help interpret the monument's complex history. These models can be used by historic building specialists in the future to analyse building materials, building phases and construction techniques and can also be used for conservation or disaster management planning; as a tool for monitoring the condition of a structure or for re-building.

Client: Brookfield
Project Leader: MOLA Geomatics

Stickyworld: Twitter Walkabouts

Free beta trials available

Stickyworld is a stakeholder engagement platform enabling presentation and detailed discussion of maps, plans, videos and 360 virtual tours. People stick digital 'post-it notes' directly on slides to leave comments. This enables feedback throughout the whole project lifecycle for any building or neighbourhood, and has been used across London in Bloomsbury, Kentish Town and Haringey for community engagement, and was also used, for example by The Design Museum, who published a 360° virtual tour of their new museum to stick comments on. Stickyworld's new beta version enables crowdsourcing of photos about a local place via twitter, before publishing in Stickyworld's visual forum for more a detailed forum discussion.

Developer: Slider Studio
Research Consultants: HTA, Cullinan Studio, Scott Brownrigg, MAKE, University of East London, Arup, Planning in the Pub and City University
Funder: Nominet Trust

The Midtown Air Quality Kiosk

Address: 88 Kingsway, London WC2
Project Status: Under development, due to complete September 2014

Central London has the poorest air quality of any European capital, an issue that cannot be underestimated and requires urgent attention. The impact it has on the population living and working in the capital is huge: the average loss of life expectancy due to poor air quality is 50% higher in London than the national average, with 4,300 premature deaths a year attributable to air pollution.

Forming part of inmidtown's sustainability action plans, a project has been developed that takes a positive step towards tackling London's air quality problem – installing an air quality monitor at the Midtown information kiosk directly outside Holborn Underground station. This location has extremely high levels of footfall, with thousands of commuters and tourists passing by every day. Currently, according to Transport for London, 179,000 customers use the station on a daily basis.

The air quality monitor measures nitrogen dioxide exposure levels experienced by commuters at this location, every 15 minutes. This information is live-streamed onto a large touchscreen display on the kiosk, via a custom-built widget, so that passers-by can see it. The data is also fed into the London Air Quality Network (LAQN) and used to support a London-wide model, called Nowcast, which maps pollution levels across London.

The aim of the initiative is twofold: to communicate poor air pollution episodes to commuters so that they can reduce their exposure levels; and to raise awareness of the air quality issue and the factors that affect it. This will translate into support from the business community for inmidtown's air quality improvement initiatives, including urban greening, walking and cycling initiatives, freight consolidation schemes and the use of hybrid vehicles for kerbside waste collections.

Researchers at Kings College London are gaining insights: "By assessing pollution levels in conjunction with wind strength and direction we are beginning to gain an understanding of how Kingsway acts as an urban canyon. The monitoring site is on the east side of Kingsway and it is during easterly winds that the highest levels of nitrogen dioxide have been measured. In the street canyon, the winds from the east pass over the road canyon, hit the buildings on the west side then come down to street level and recirculate back across to the east side, bringing the emissions from traffic with it. The opposite occurs during westerly winds."

This initiative has the potential to be rolled out at other high footfall sites on the LAQN where additional support for air quality improvement initiatives is required from the business community.

"Never before in London has the data from an air quality monitoring station been displayed in real-time to the public at the location of that station. To do so would not only be a first but would also help greatly in both the communication of pollution information and in how it is monitored. The monitoring analyser located in the inmidtown kiosk is unique in London in that the kiosk also has a giant public display screen. This project has the opportunity to harness this unique combination to bring pollution information from the online realm to the public realm."
Andrew Grieve, Air Quality Analyst, King's College London

"The air quality monitoring station and real time display in the inmidtown information kiosk is an important way of helping raise awareness of air quality issues amongst the public in London. It complements the action being taken by the Mayor to tackle emissions from buildings, buses and taxis. I hope to see similar initiatives from other business improvement districts and applaud inmidtown for their leadership on this important issue."
Matthew Pencharz, Mayor's Senior Advisor - Environment and Energy

Project Team
Project Lead: inmidtown
Air Quality Analyst: Andrew Grieve
Environmental Research Group: King's College London

Tass Mavrogordato, Chief executive
inmidtown

Our key challenge was to find a way to engage with people in order to highlight the issues surrounding air quality in our capital. We felt that displaying complex local air quality data in plain and simple terms would be the first step.The solution was to keep it simple by using existing infrastructure. The Midtown information kiosk, an established focal point for information-sharing, is situated in a prime location to cater for heavy pedestrian traffic. It has also just had a green roof installed, an expression of our commitment to improve air quality in the area.

There were a range of challenges associated with the delivery of this project. There were practical challenges, such as having to install a small air conditioning unit alongside the monitoring equipment to keep it within an optimal temperature range; technical issues, involving the real-time updating of display information based on readings from the monitoring equipment; and social considerations, such as the best way to display complex data in a meaningful and engaging manner. We worked with equipment manufacturers, King's College London and our own marketing agency to overcome the challenges associated with this project.

Monitoring the Kiosk will help provide local information for inmidtown to use in its action plans, as well as contributing to a greater understanding of pollution behaviour within the urban environment.

The Regent Street Smart iPhone App

Address: Regent Street, London W1
Project Status: Under development, due to complete September 2014

In July 2014, Regent Street became the first shopping street in Europe to pioneer a unique iPhone app and beacon technology to deliver exclusive, personalised content to shoppers during their visit. With a street frontage of two kilometres, 20,000 people working and more than 7.5 million tourists visits a year, Regent Street is one of the busiest of London's walkways. The new app enables shoppers to create a unique personal shopping experience, with event information, updates, news and promotions from the brands they love, as well as finding new ones that suit them.

The app is currently available on iOS and once users have downloaded the app, they can tailor it to deliver content specific to the brands they like that appear on Regent Street. The app then communicates with beacons located in each store; if the offer is relevant and matches that user's app profile, they will receive a notification on their phone. This might include information about new products and upcoming events, or exclusive offers only available to those shopping on the street that day.

The app will also enable shoppers to better explore what the street has to offer, helping them plan their visits and introducing them to new brands that align with their interests. A key benefit of the app for shoppers is the ability to input their store preferences whilst still maintaining their anonymity.

The beacon technology used has only previously been trialled by a handful of retailers but because it is powered by Bluetooth, this comes at no cost to the user. The beacons use the 'Bluetooth Low Energy' system which consumes a lot less power, opening up wider applications for the technology. They are energy efficient and able to continually transmit offers for up to two years before the battery requires changing.

The introduction of the app forms part of the £1 billion Regent Street regeneration programme, which has already seen an array of internationally renowned brands like Burberry, J Crew and Anthropologie open global flagship stores on the Street. The app, which is free to download, includes information from the majority of Regent Street's world leading retail line-up.

The street's Grade II listed facades provide a striking backdrop for visitors to post images and feedback from their visit using one of Regent Street's six social media platforms. Rated 5* on Apple's App Store, feedback from users and retailers alike is encouraging. An Android version is planned for the future.

"Success in retail in the 21st century is strongly linked to how you engage your customers in store and online. Regent Street already has a reputation as being the place to be for brands like ours and the new mobile app will bring the digital and physical together, providing an exciting new way for us to speak to our customers."
Paul Lorraine, UK General Manager of Longchamp

Project Team
Client: The Crown Estate
Project Manager: Regent Street Association
Developer: autoGraph

"We are delighted Regent Street is the first shopping street in Europe to utilise beacon technology. The retailers have embraced this initiative and understanding it is the way forward, fully support the digital advancements. The Regent Street app is perfect as it enables the customer to choose the brands they wish connect too but does not track their data."
Annie Walker, Director, The Regent Street Association

David Shaw, Head of the Regent Street Portfolio
The Crown Estate

This is a fantastic example of how Regent Street is continuing to evolve as the world's most successful shopping destination, bringing together online, physical and now mobile retailing to provide an experience which delivers across all of the platforms that appeal to 21st century shoppers.

@RegentStreetW1
www.regentstreetonline.com

White Collar Factory

Address: Old Street Yard, London EC1
Project Status: On site, due to complete August 2016

White Collar Factory is a new 237,000 square foot landmark office building at Old Street EC1 in London's 'Tech Belt', which hopes to revolutionise the workplace. Aiming to provide innovative and sustainable design for the future, it will form the centrepiece of a new urban campus for London, with an additional five low-rise buildings containing 39,200 square feet of flexible workspace, three restaurants and 8,000 square feet of residential units clustered around a new public courtyard, Old Street Yard.

Derwent London has always favoured the robustness and adaptability of buildings of the industrial era more than the over-specified and potentially short-lived new builds of recent years. Simple, yet generous, these older buildings readily transform into inspiring, people-centric space. They don't demand excessive 'cooling' systems because they're blessed with high ceilings, great daylight and natural ventilation.

With sustainability and flexibility in mind, White Collar Factory is built around five simple principles: high ceilings, windows that open, concrete core cooling, flexible occupation, stays cool and stays warm.

Concrete Core Cooling is integrated into the building's design and structure. Unlike conventional air conditioning, it is a passive cooling system which is quieter to run with less air movement within the space, providing an outstanding working environment. It works with the thermal mass of the building's concrete structure to absorb the heat generated in the office. The heat is then transferred by a network of chilled water pipes embedded in the concrete, providing radiant cooling and controlling the office environment.

"People might think the WCF idea is radical. It's different, of course, as we designed it to move the discourse forward and to challenge. But in the end, like all new ideas, it's an old idea reinvented. Its elements already exist elsewhere; we've just brought it all together. It could work equally well for architects, designers, lawyers, publishers, internet companies and so on. It could and should be for everybody."
Simon Allford, AHMM

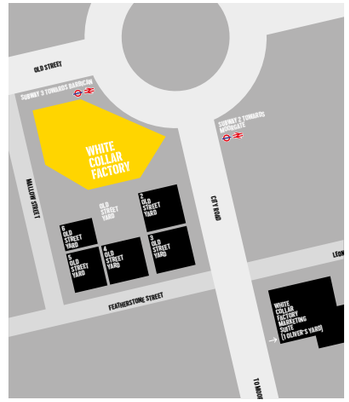
The project hopes to demonstrate exemplary sustainability credentials, minimising impact on the environment during construction and operation. It will aim for BREEAM Excellent. Total recycled content will exceed 20 per cent (by cost), and will provide user energy savings between 15-26 per cent on conventional office buildings.

A key example of White Collar Factory's sustainable features is for users to have control over their localised environment. A specialist building management app has been developed by Arup to enable user-friendly interactive control of heating and cooling. It allows occupiers to feel in control of the space, for example telling them the optimum times to open windows.

The design of White Collar Factory brings the Building Management System (BMS) out of the basement and the sole control of facilities management and into the hands of the people who will work there. White Collar Factory's building services – its ventilation, cooling, heating, lighting etc – have been designed to link to a BMS which building occupants are able to access and adjust. The BMS has been configured with a user app for those working at White Collar Factory to orientate themselves, check internal conditions in their immediate area and interact with the building in order to improve comfort and energy efficiency. Arup's building services design, developed in collaboration with AHMM and Derwent London, heralds the arrival of 'smart servicing'.

"Technological, sociological and environmental changes are making traditional approaches to providing office space redundant… It's time to be brave and radically rethink the space we provide."
Benjamin Lesser, Derwent London

Project Team
Client: Derwent London plc
Architect: Allford Hall Monaghan Morris (AHMM)
M&E & Structural Engineer: Arup
Project Manager: Jackson Coles
Quantity Surveyor: AECOM
Contractor: Brookfield Multiplex

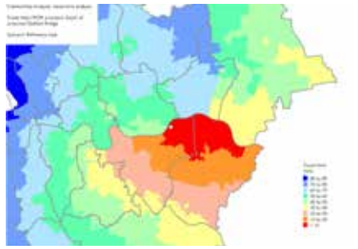


"Funky office space and locations are important to technology companies because they are so reliant on attracting and retaining top talent."
Wall Street Journal online

"Inefficient buildings cost British business £135bn per annum and a better-designed workplace could improve productivity by 19 per cent"
Gensler

"There's a good reason why sustainable buildings are also known as 'high performance buildings': they not only tend to save on running costs, there is also growing evidence that they can increase productivity and well-being for occupants through improved light and air quality."
Beatrice K Otto, Sustainable Office Design

whitecollarfactory.com
@WCF_OldStYard
#whitecollarfactory



Thames River Crossings Development Study

Under development

There are only two road crossings east of Tower Bridge, creating a 'barrier effect' that limits firm's access to markets, the size of retail and leisure catchments, and resident's access to employment. Atkins produced a set of future land use scenarios, including potential development and socio-economic impacts for all TfL road-crossing options. Analysis of Saturn modelling data was critical in identifying current accessibility issues within the study area. Smart technology facilitated the understanding of complex and dynamic socio-economic interrelationships that could influence the regeneration of east London.

Developer & Project Manager:
Atkins Economics and
Planning Team

The Francis Crick Institute

Under development, due to complete November 2015

Aiming to create a world-class centre for biomedical research, this constrained site required early strategic 'smart' decisions to solve the complex balance between required volume, planning sensitivities and an array of underground adjacencies. A bespoke hybrid basement construction methodology was coupled with a full 3D finite element ground model that was used to define a real-time monitoring regime of the surrounding structures linked to a set of predefined contingency plans. Collected real data will further develop the accuracy of ground modelling and basement design.

Architect: HOK with PLP Architecture
Structural Engineer: AKT II
Cost Consultant:
Turner & Townsend

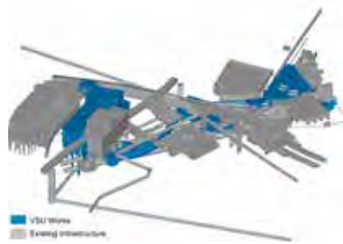
M&E Consultant & Project Manager: Arup
Contractor: Laing O'Rourke

Velux Carbonlight Houses

Homes occupied throughout 2013

The performance of two demonstration houses, built and occupied throughout 2013, were measured through a combined quantitative and qualitative assessment. Two families occupied the houses over a 9- & 12-month period of assessment. The factors measured were temperature, relative humidity, CO_2 concentration and daylight levels. A Building Management System monitored the readings at quarter-hour intervals and the living experiences of the occupants were documented through bimonthly questionnaires, phone interviews and blog entries. Energy and carbon consumption data were also assessed, as well as the families' lifestyle and its changes over the monitoring period.

Architect & Sustainability Consultant: HTA Design LLP
Client: Velux



Victoria Underground Station

Under development

Starting in 2006, the redevelopment and modernisation of Victoria Underground Station pushed the use of BIM far beyond anything then previously attempted in the UK. It includes a new entrance and ticket hall, passenger tunnels, step-free access and doubling in size an existing ticket hall, while the station remains open. Cutting-edge design of shallow sprayed concrete-lined tunnels through jet-grout stabilised water-bearing gravels has minimised settlement impact on adjacent buildings.

Client: London Underground
Contractors:
Taylor Woodrow-BAM Nuttall
Project Designer:
Mott MacDonald

Tower Hamlets Carbon Offset Databases and GIS mapping tool

Under development, due to complete September 2014

In order to deliver carbon savings, reduce fuel poverty and create local jobs – particularly through energy-efficient retrofits – the Carbon Offset Fund has developed two databases compiling data from a number of sources and integrating energy modelling. These aim to bridge the gap between strategic decisions and individual projects. The domestic version serves over 8,000 properties in the social housing sector across the borough, with the non-domestic version serving over 130 public buildings. The GIS tool incorporates information from the above databases on maps, and enables visualisation of these buildings' energy performance and carbon saving potential, reducing perceived complexity of energy efficiency for the community.

Client: LB Tower Hamlets
Sustainability Practice: Etude

University Campus Research Project

Completed May 2013

Northumbria University's city campus is being used to pilot BIM protocols to manage its 32 city centre non-residential buildings, with a gross area of over 120,000sqm. The ambition is to develop from the smart management of individual buildings to building complexes and whole city quarters, optimising the operations of both buildings and infrastructure, particularly business critical and low carbon aspects. Building on this project and others, combined with 18 months of intensive research, Ryder and BIM Academy have now launched a consultancy offer covering BIM for Asset and Facilities Management (BAFM).

Client: Northumbria University
Research: BIM Academy
(JV between Ryder Architecture and Northumbria University)

Vision for Gatwick

Design stage, due to complete in 2025

Farrells' proposed new hub at Gatwick connects multiple transport systems and anticipates customer expectations in ten years time. The design would enable passengers to check in and bag-drop before arriving at the airport, walk through security pre-cleared for immigration, have dedicated baggage reclaim pods and fully integrated onward transport networks. The 'Drive Through Terminal' maximises aircraft turnarounds and passenger experience whilst condensing footprint and shortening walking distances. The lounge enables personalised notifications to devices and personalised wayfinding to flights, whilst flow of aircraft is controlled in a highly managed way.

Client: Gatwick Airport
Masterplanner & Architect:
Farrells

Vital Signs

Completed in 2010

Using data-feeds and digital readings from the building management system, this project translates this information into abstract form. The LED bars of the artwork are illuminated with five colours, each corresponding to a different aspect of the inner activity of the building, from its green energy production and harvested rainwater, to its power consumption, differential between internal and external temperature, and lift operation. Conceived by the artist as an "electrocardiogram for the entire building", the dynamic light installation shows in real time what is happening inside.

Client: The Crown Estate
Artist: Spencer Finch
Art Consultant: Modus Operandi
Architect: Dixon Jones
Development Manager:
Stanhope

Main Contractor:
Sir Robert McAlpine
Mechanical & Electrical Consultant: AECOM

Profiles

ARUP

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@arupdigital

Arup is the creative force at the heart of many of the world's most prominent projects in the built environment and across industry. The company offer a broad range of professional services that combine to make a real difference to clients and the communities in which they work.

From 90 offices in 38 countries Arup's 11,000 planners, designers, engineers and consultants deliver innovative projects across the world with creativity and passion.

Founded in 1946 with an enduring set of values, their unique trust ownership fosters a distinctive culture and an intellectual independence that encourages collaborative working. This is reflected in everything they do, allowing the company to develop meaningful ideas, help shape agendas and deliver results that frequently surpass the expectations of clients.

Arup shapes a better world.

PARSONS BRINCKERHOFF

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@pbworld

Parsons Brinckerhoff is a global consulting firm assisting public and private sector clients to plan, develop, design, construct, operate and maintain critical infrastructure around the world.

With 14,000 employees worldwide, the company is engaged in a wide range of projects, from initiatives that shape an entire region, to smaller, local projects that define a community.

The company provides services for all modes of infrastructure, including transportation, power, energy, community development, water, mining and the environment.

As experienced technical practitioners and programme managers, Parsons Brinckerhoff's employees apply practical, innovative, collaborative, sustainable and internationally tested solutions to deliver outcomes that benefit clients and the wider community.

Internationally, Parsons Brinckerhoff is designing sustainable, high-rise developments such as the Shanghai Tower. The company is working on complex mass transit assignments, for example the California High Speed Rail Project, and collaborates with multiple stakeholders to work on vital power transmission and distribution projects in Africa.

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Credits

This Insight Study was published by NLA in October 2014. It accompanies the NLA exhibition 'Smarter London – how digital technologies are shaping the city' and events programme taking place from October to December 2014.

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NLA have collaborated with CASA to produce the research for this Insight Study.

The Bartlett Centre for Advanced Spatial Analysis (CASA) is one of the leading forces in the science of cities, generating new knowledge and insights for use in city planning, policy and design and drawing on the latest geospatial methods and ideas in computer-based visualisation and modelling. The centre is the first in the UK to launch an MSc in Smart Cities and Urban Analytics. The course is aimed at training professionals in data analysis and the built environment, opening up new and emerging fields in the Smart Cities arena.

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References

Chapter one

[1] 'World population projected to reach 9.6 billion by 2050' (13 June 2013) (online: http://www.un.org/en/development/desa/news/population/un-report-world-population-projected-to-reach-9-6-billion-by-2050.html, accessed on 30 July 2014).

[2] World Health Organization, 'Urban population growth' (online: http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/, accessed on 30 July 2014).

[3] Smart London Plan, p. 2. Greater London Authority, Smart London Plan (December 2013), p. 1; Greater London Authority, *Long Term Infrastructure Investment Plan for London: Progress Report* (March 2014), p. 6.

[4] *Smart London Plan*, p. 10.

[5] Nicholas You, cited by Davina Jackson and Richard Simpson (eds.), DCity: *Connecting Global Futures for Environmental Planning* (2012), p. 19.

[6] *Smart London Plan*, p. 3.

[7] Nicholas You, cited by Davina Jackson and Richard Simpson (eds.), DCity: *Connecting Global Futures for Environmental Planning* (2012), p. 19.

[8] Future Cities Catapult, *How can the UK Innovate for the World's Cities?* (2014), p. 4.

[9] http://www.samsung.com/uk/consumer/mobile-devices/wearables/gear/SM-R3800VSABTU, accessed on 4 August 2014; http://store.nike.com/gb/en_gb/pw/nike-fuelband-se/d4d?cp=EUNS_KW_UK_4_Fuelband, accessed on 4 August 2014.

[10] http://www.microtec.eu/en/solutions/manufacturing/system-solution, accessed on 4 August 2014; http://www.bbc.co.uk/iplayer/episode/b04cnps9/the-fifteen-billion-pound-railway-3-platforms-and-plague-pits, accessed on 4 August 2014; http://www.wiehag.com/en/home/news/news-details/LbrDateEntry/23.html, accessed on 4 August 2014.

[11] https://www.youtube.com/watch?v=AVVH4FIdr7Y, accessed on 4 August 2014; http://www.bre.co.uk/news/Reinventing-the-house-of-the-future-909.html, accessed on 4 August 2014.

[12] Davina Jackson and Richard Simpson (eds.), *DCity: Connecting Global Futures for Environmental Planning* (2012), p. 81

[13] http://share.cisco.com/internet-of-things.html, accessed on 4 August 2014.

[14] RIBA and Arup, *Designing with Data: Shaping our Future Cities*, p. 2.

[15] Francis Maude, *Foreword, Open Data White Paper: Unleashing the Potential* (June 2012).

[16] Francis Maude, Foreword, *Open Data White Paper: Unleashing the Potential* (June 2012); London Datastore (http://data.london.gov.uk).

[17] RIBA and Arup, *Designing with Data: Shaping our Future Cities*, p. 19.

[18] Energy Saving Trust, *The Rise of Machines: a review of energy using products in the home from the 1970s to today* (2006), p. 6; Energy Saving Trust, *The Elephant in the Living Room: how our appliances and gadgets are trampling the green dream* (2011), p. 24.

[19] Arup, cited in Department for Business Innovation & Skills, *Smart Cities: Background Paper* (October 2013), p. 3.

[20] *Smart London Plan*, p. 28.

Chapter two

[21] RIBA and Arup, *Designing with Data: Shaping our Future Cities*, p. 2.

[22] Rebecca Roberts-Hughes and Anna Scott-Marshall (ed.), 'City Health Check: How design can save lives and money', (London: RIBA, December 2013), p. 2.

[23] The Bartlett Centre for Advanced Spatial Analysis, 'CASA PhD Student Panos Mavros features on Sky News' (8 April 2014), (online: http://www.bartlett.ucl.ac.uk/casa/news/2014-04-08-sky-news-panos-mavros, accessed 18 August 2014).

[24] Tom Platt, 'Sight and the City: Brain Scan Tech Analyses How Blind People Get Around', Medium (30 March 2014), (online: https://medium.com/@trplatt/sight-and-the-city-a3f41eed5aeb, accessed 18 August 2014).

[25] Hayes Davidson, 'City Analytics' (online: http://www.hayesdavidson.com/cityanalytics, accessed 18 August 2014).

[26] Nadstar, Hayes Davidson map of Protected Viewing Corridors (online: http://www.nadstar.com/clients/hd/lvmf_full/v2/, accessed 18 August 2014); 'Interactive Map', *Looking at London: City Analytics*, Hayes Davidson LVMF blog, on Blogspot (14 August 2009), (online: http://hdlvmf.blogspot.co.uk/2009/08/interactive-map-lite.html, accessed 18 August 2014).

[27] Space Syntax, 'Earls Court' (online: http://www.spacesyntax.com/project/earls-court/, accessed 19 August 2014).

[28] Space Syntax, 'Waterloo: South Bank' (online: http://www.spacesyntax.com/project/waterloo-south-bank/, accessed 19 August 2014).

[29] C. Harmer (Crossrail), 'Modelling Passenger Exchange at Crossrail Stations' (online: http://abstracts.aetransport.org/paper/index/id/3659/confid/17, accessed 18 August 2014).

[30] Arup, 'The Impact of Crossrail on Visitor Numbers in Central London', prepared for on behalf of the New West End Company, inmidtown, the Fitzrovia Partnership and Transport for London, working with Crossrail Ltd, Camden Council and the City of Westminster (January 2014), p. 1-14.

[31] Transport Buzz, created by Transport API (online: http://transportbuzz.com, accessed 18 August 2014).

[32] Commonplace, 'Case Study: West Hampstead' (online: https://westhampstead.commonplace.is, accessed 19 August 2014); Nicky Jones, 'What do locals think of West Hampstead?', West Hampstead Life (26 February 2014), (online: http://westhampsteadlife.com/2014/02/26/what-do-locals-think-of-west-hampstead/11086, accessed 19 August 2014).

[33] Commonplace, 'Commonplace: Crowd-sourced insight for better living spaces' (online: www.cprelondon.org.uk/events/current-events/item/download/745, accessed 19 August 2014).

[34] Commonplace, 'Commonplace: Crowd-sourced insight for better living spaces' (online: www.cprelondon.org.uk/events/current-events/item/download/745, accessed 19 August 2014).

[35] Flickr, 'The Geotaggers' World Atlas', (online: https://www.flickr.com/photos/walkingsf/sets/72157623971287575/, accessed 19 August 2014).

[36] Streetscore, 'About', (online: http://streetscore.media.mit.edu/about.html, accessed 18 August 2014).

[37] SENSEable City Lab, 'One Country Two Lungs' (online: http://senseable.mit.edu/twolungs/, accessed 19 August 2014).

[38] Illustreets (online: http://illustreets.co.uk, accessed 19 August 2014)

References

[39] Brenda Boardman, *Home Truths: A Low-Carbon Strategy to Reduce UK Housing Emissions by 80% by 2050,* University of Oxford's Environmental Change Institute, research report for The Co-operative Bank and Friends of the Earth (Oxford: University of Oxford, November 2007), p. 6; Gavin Killip, *Transforming the UK's Existing Housing Stock*, Environmental Change Institute, a report for the Federation of Master Builders (Oxford: University of Oxford, 2008), p. 4.

[40] The Kadaster, 'The Kadaster Corporate English', (YouTube, March 2013) (online: https://www.youtube.com/watch?v=_U9TpQpZIdc&feature=youtu.be, accessed 18 August 2014).

[41] The Kadaster, 'The Kadaster Corporate English', (YouTube, March 2013) (online: https://www.youtube.com/watch?v=_U9TpQpZIdc&feature=youtu.be, accessed 18 August 2014).

[42] Andrea Barry and Jay Mezher, 'Digital City Models for Civil Design', CE News (February 2013), (online: http://www.cenews.com/article/9190/digital-city-models-for-civil-design, accessed 18 August 2014); Parsons Brinckerhoff, Vimeo page for Seattle model (online: http://vimeopro.com/projectviz/digital-cities/video/53871522, accessed 18 August 2014); Autodesk, 'Parsons Brinckerhoff Customer Success Story Story: Visualising Seattle' (2010) (online: http://images.autodesk.com/adsk/files/parsons_brinckerhoff_customer_story.pdf, accessed 18 August 2014).

[43] Thomas Schueneman, 'Seattle 3D Model: A Prototype for Sustainable Urban Development', *Triple Pundit* (11 March 2013), (online: http://www.triplepundit.com/2013/03/seattle-city-3d-model-prototype-urban-planning-sustainable-urban-development/, accessed 18 August 2014).

[44] Brandon Liu's website (online: http://bdon.org/cad/, accessed 18 August 2014); Rory Stott, 'Free CAD Files of 241 Major World Cities', ArchDaily (8 August 2014), (online: http://www.archdaily.com/535628/free-cad-files-of-241-major-world-cities/?utm_source=dlvr.it&utm_medium=twitter, accessed 18 August 2014).

[45] CASA, 'CASA Collaborates with the Future Cities Catapult' (29 May 2014), (online: http://www.bartlett.ucl.ac.uk/casa/news/2014-05-22-fcc-collaboration, accessed 18 August 2014).

Chapter three

[46] Greater London Authority, *Smart London Plan* (December 2013), p. 10.

[47] Stephen Walter, 'London Subterranea' (online: http://www.stephenwalter.co.uk/wp/maps/london-subterranea/, accessed 12 August 2014).

[48] Department of Energy & Climate Change, 'Maintaining UK Energy Security' (updated 23 June 2014) (online: https://www.gov.uk/government/policies/maintaining-uk-energy-security--2/supporting-pages/future-electricity-networks, accessed 12 August 2014).

[49] Department of Energy & Climate Change, 'Maintaining UK Energy Security' (updated 23 June 2014) (online: https://www.gov.uk/government/policies/maintaining-uk-energy-security--2/supporting-pages/future-electricity-networks, accessed 12 August 2014).

[50] Islington Council, 'Cheaper, greener energy in Islington: Bunhill Heat and Power' (online: http://www.islington.gov.uk/services/parks-environment/sustainability/energy-services/Pages/bunhill-heat-power.aspx, accessed 12 August 2014).

[51] The Independent, 'Exclusive: Renewable energy from rivers and lakes could replace gas in homes' (23 March 2014) (online: http://www.independent.co.uk/environment/climate-change/exclusive-renewable-energy-from-rivers-and-lakes-could-replace-gas-in-homes-9210277.html, accessed 12 August 2014); The Independent, 'An energizing breakthrough that could help lower carbon dioxide emissions' (23 March 2014) (online: http://www.independent.co.uk/voices/editorials/an-energising-breakthrough-that-could-help-lower-carbon-dioxide-emissions-9210172.html, accessed 12 August 2014).

[52] Pavegen, 'Press Release: Pavegen Launches Student Powered School' (5 September 2013).

[53] Department of Energy & Climate Change, *Smart Metering Implementation Programme: Smart Metering Summary Plan* (18 December 2013), p. 3.

[54] Haringey Heat Loss Map (online: http://www.parthiansystems.co.uk/haringey/, accessed 12 August 2014).

[55] Living in a Sustainable World Focused on Electrified Rail, 'TFL Oyster Card' (online: http://81.47.175.201/livingrail/index.php?option=com_content&view=article&id=703:tfl-oyster-card&catid=30:rail-oriented-policies&Itemid=104, accessed 12 August 2014).

[56] Phil Young, Head of Online at Transport for London, TFL Digital Blog, 'Why a new website but no app?' (12 March 2014) (online: http://blog.tfl.gov.uk/2014/03/12/why-a-new-website-but-no-app-part-2/, accessed 12 August 2014).

[57] Source London (online: https://www.sourcelondon.net/about-us, accessed 12 August 2014).

[58] Fully Charged, 'The National Grid' (2 May 2012) (online: https://www.youtube.com/watch?v=vX0G9F42puY, accessed on 12 August 2014).

[59] Larry Burns, advisor to Google's self-driving car project, cited by ABC News, 'Driverless car may ease city parking demands, ex-GM executive Larry Burns says' (6 August 2014) (online: http://www.abc.net.au/news/2014-08-06/driverless-car-might-end-city-parking-demands-larry-burns/5651688, accessed 12 August 2014).

[60] Forbes, 'Fasten Your Seatbelts: Google's Driverless Car is Worth Trillions' (22 January 2013) (online: http://www.forbes.com/sites/chunkamui/2013/01/22/fasten-your-seatbelts-googles-driverless-car-is-worth-trillions/, accessed 12 August 2014); TED Talks, 'Sebastian Thrun' (online: http://www.ted.com/talks/sebastian_thrun_google_s_driverless_car#t-48228, accessed 12 August 2014); ABC News, 'Driverless car may ease city parking demands, ex-GM executive Larry Burns says' (6 August 2014) (online: http://www.abc.net.au/news/2014-08-06/driverless-car-might-end-city-parking-demands-larry-burns/5651688, accessed 12 August 2014).

[61] Department for Business, Innovation & Skills and Department for Transport, 'UK Government fast tracks driverless cars' (30 July 2014) (online: https://www.gov.uk/government/news/uk-government-fast-tracks-driverless-cars, accessed 12 August 2014).

[62] Parsons Brinckerhoff, *Digital Life, Digital Legacy* (June 2014), p. 62-63.

[63] BBC News, 'Going underground in London's 'smart tunnels'' (16 June 2014) (online: http://www.bbc.co.uk/news/technology-27716534, accessed 12 August 2014).

[64] Crossrail, 'Crossrail Implements Lorry Requirements to Improve Cycle Safety' (22 February 2012) (online: http://www.crossrail.co.uk/news/articles/crossrail-implements-lorry-requirements-to-improve-cycle-safety, accessed 12 August 2014); Crossrail, 'Meet Our Giant Tunneling Machines' (online: http://www.crossrail.co.uk/construction/tunnelling/meet-our-giant-tunnelling-machines/, accessed 12 August 2014).

[65] ESRI UK, 'Transforming businesses processes enterprise-wide: Thames Water (online: http://www.esriuk.com/sites/default/files/CaseStudyDocuments/esri_uk_thameswater.pdf, accessed 12 August 2014).

[66] Barnsnape Consulting, 'Thames Water: GIS Foundation Programme', online: http://www.barnsnape.com/img/thames-water-gisf-delivery.pdf, accessed 12 August 2014).

[67] Greater London Authority, 'Drain London Project' (online: https://www.london.gov.uk/priorities/environment/looking-after-londons-water/drain-london, accessed 12 August 2014).

Chapter four

[68] Richard Waterhouse, CEO, NBS and RIBA Enterprises, 'Introduction', NBS National BIM Survey (April 2014), p. 2.

[69] Richard Waterhouse, CEO, NBS and RIBA Enterprises, 'Introduction', NBS National BIM Survey (April 2014), p. 2.

[70] Stanford University Centre for Integrated Facilities Engineering (2007), cited by Lincoln H. Forbes and Syed M. Ahmed in *Modern Construction: Lean Project Delivery and Integrated Practices* (Florida: Taylor Francis, 2011), p. 217.

[71] Wallbank, p. 1

[72] Plowman Craven, 'Broadgate Arena' (online: http://www.plowmancraven.co.uk/projects/broadgate-arena/, accessed 27 August 2014); Plowman Craven, '3D Laser Scanning' (online: http://www.plowmancraven.co.uk/services/3d-laser-scanning-and-modelling/3d-laser-scanning/, accessed 27 August 2014).

[73] The Leadenhall Building, 'Construction and Architectural Facts' (online: http://www.theleadenhallbuilding.com/SiteResources/pdfs/TheLeadenhallBuilding_Construction.pdf, accessed 29 August 2014).

[74] Laing O'Rourke, (online: http://www.laingorourke.com/our-work/all-projects/the-leadenhall-building.aspx, accessed 29 August 2014).

[75] Tekla, 'Project OVE: Arup's 170-metre-tall BIM man' (online: http://www.tekla.com/references/project-ove-arups-170-meter-tall-bim-man, accessed 27 August 2014).

[76] (Jack White, 'Arup Group talk Project OVE with Construction Manager', BIM News, 6 May 2014 (online: http://www.bimcrunch.com/index.php/component/k2/item/907-arup-group-talk-project-ove-with-construction-manager, accessed 26 August 2014).

[77] 'Arup team trials 'Body Information Modelling' to engage engineers', Construction Manager (4 May 2014), (online: http://www.construction-manager.co.uk/news/arup-bim-team-trial-body-information-modelling/, accessed 26 August 2014); Arup, 'BIM Trial Project OVE', (online: http://www.arupassociates.com/en/exploration/books/bim-trial-project-ove/, accessed 26 August 2014)

[78] BIM.Technologies, '240 Blackfriars Road' (online: http://www.bimtechnologies.co.uk/case-studies/view/9/240-blackfriars-road, accessed 27 August 2014); Great Portland Estates, '240 Blackfriars Road' (online: http://www.gpe.co.uk/property/our-portfolio/southwark/240-blackfriars-road.aspx, accessed 27 August 2014); Martin Quinn, Project Manager, 'Unlocking Potential: BIM: A Developers View', NBS/NLA BIM Conference October 2012 (online: www.newlondonarchitecture.org/dl/bimfr001/pdf810_martin_quinn_, accessed 27 August 2014); Thomas Lane, 'Building's new home: 241 Blackfriars Road', *Building*, 19 July 2013 (online: http://www.building.co.uk/buildings-new-home-240-blackfriars-road/5057489.article, accessed 27 August 2014).

[79] Mel Allwood, 'The White Collar Factory – the future is here', *UK Green Building Council* (14 November 2013), (online: http://www.ukgbc.org/opinion/white-collar-factory-future-here, accessed 22 August 2014); World Buildings Directory Online, 'White Collar Factory' (online: http://www.worldbuildingsdirectory.com/project.cfm?id=5029, accessed 22 August 2014).

[80] Apple Store, 'Old Street Yard app' (online: https://itunes.apple.com/gb/app/old-street-yard/id648834442?mt=8, accessed 27 August 2014); Arup, 'Empowering efficiencies: exploring how strategic, technological and design innovations can enable high performing businesses', *A2 Magazine,* Issue 14 (Beacon Press).

[81] Mel Allwood, 'The White Collar Factory – the future is here', *UK Green Building Council* (14 November 2013), (online: http://www.ukgbc.org/opinion/white-collar-factory-future-here, accessed 22 August 2014); Thomas Lane, 'Derwent London's white collar factory', *Building* (10 May 2013), (online: http://www.building.co.uk/derwent-londons-white-collar-factory/5053934.article, accessed 22 August 2014).

[82] The Housing Forum, 'Section 6: Tools for Change', *Housing for the Information Age*, October 2013 (online: http://www.housingfortheinformationage.co.uk/sections/6/tools-for-change, accessed 27 August 2014); Ben Derbyshire, 'Ben Derbyshire's Building Blog 21.08.13' (online: http://www.hta.co.uk/news/posts/housing-for-the-information-age, accessed 22 August 2014).

[83] Shelagh Grant, The Housing Forum, 'Mind the Gap website is LIVE | An experimental home performance labelling pilot by The Housing Forum' (16 April 2014), (online: http://housingforum.org.uk/news/mind-gap-website-live-experimental-home-performance-labelling-pilot-housing-forum, accessed 22 August 2014); http://www.mindthe-gap.info/web/uploads/files/MTG_Download1.pdf.

[84] Stephen Cousins, 'How can construction solve the housing crisis?', *Construction Manager* (7 July 2014), (online: http://www.construction-manager.co.uk/agenda/how-can-we-solve-housing-crisis/, accessed 20 August 2014).

[85] GLA, Press Release, "Mayor announces developer to build Royal Docks 'floating village'", (23 July 2014), (online: http://www.london.gov.uk/media/mayor-press-releases/2014/07/mayor-announces-developer-to-build-royal-docks-floating-village, accessed 27 August 2014); Construction Manager, 'Carillion-Igloo floats another housing innovation', (25 July 2014), (online: http://www.construction-manager.co.uk/news/carillion-igloo-floats-another-housing-innovation/, accessed 22 August 2014).

[86] Stephen Cousins, 'How can construction solve the housing crisis?', Construction Manager (7 July 2014), (online: http://www.construction-manager.co.uk/agenda/how-can-we-solve-housing-crisis/, accessed 20 August 2014).

[87] WikiHouse, 'About', (online: http://www.wikihouse.cc/about#step-overview, accessed 27 August 2014); Alastair Parvin, TEDTalk, 'Architecture for the people by the people' (February 2013) (online: http://www.ted.com/talks/alastair_parvin_architecture_for_the_people_by_the_people?language=en, accessed 27 August 2014).

[88] Dezeen, 'Foster + Partners to 3D print buildings on the moon', (31 January 2013), (online: http://www.dezeen.com/2013/01/31/foster-partners-to-3d-print-buildings-on-the-moon/, accessed 26 August 2014).

[89] European Space Agency, 'Building a lunar base with 3D printing', (31 January 2013), (online: http://www.esa.int/Our_Activities/Technology/Building_a_lunar_base_with_3D_printing, accessed 27 August 2014).

Index

Projects in bold indicate schemes described in the Project Showcase