HM Government

Digital Built Britain

Level 3 Building Information Modelling - Strategic Plan

February 2015

UCL

Digital Built Britain

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The FIATECH James B Porter Jr. Award, presented to HM Government (UK) and UK Construction industry in 2013 in recognition the success of the Level 2 BIM programme

Revision

1	Issued for comments	15/6/14	MDB
2	Comments Updated & issued to Core Team	18/6/14	MDB
3	Final Issue for comments	10/7/14	MDB
4	Final Issue (4.1)	15/10/14	MDB

1. Ministerial Foreword

Construction is a sector where Britain has a strong competitive edge. We have world class capability in architecture, design and engineering and British companies are leading the way in delivering sustainable construction solutions. It is also a sector with considerable growth opportunities with the global construction sector forecast to grow by up to 70% by 2025.

We are not starting from scratch. The Government in collaboration with industry has already committed to the Level 2 BIM programme as well as investing £220M in the development of a High Performance Computing programme and over £650M in the delivery of transformational high speed Broadband across the UK by 2015. We have a recent track record of world class construction deliveries such as the 2012 Olympics and Crossrail the largest construction project in Europe now reaching the half-way point. We have seen the global reaction to our Level 2 BIM programme's successful delivery and significant cost savings which have greatly assisted the construction costs savings of £840M in 2013/4, with several major EU nations including France and Germany announcing similar BIM programmes.

If we want to retain our strength in this economy we cannot stand by. We need concerted joint action from Government, Industry and Academia working in partnership toward the success of the sector and ensuring that benefits are felt across the rest of the economy. The Information Economy is transforming the way we live and work. It is crucial to our success on the global stage and to facing the challenges of urbanisation and globalisation that we grasp the opportunity that Digital Built Britain presents.

Rt Hon Dr Vince Cable MP

Secretary of State for Business, Innovation and Skills and President of the Board of Trade

2. Industry Foreword

The time has come for the construction sector to reform by seizing the opportunities offered by the Digital Economy. Our citizens and assets are becoming ever more complex, the demands on finite resources more challenging and the need to look overseas for growth and opportunity has never been more pressing.

The Digital Built Britain strategy builds on the achievements of the Level 2 BIM programme. This has allowed projects such as Cross Rail, the 2012 Olympics, Cookham Wood Prison and a whole host of other projects to refine our approach, deliver the standards, methods and tools and demonstrate that significant learning and savings can be made through the use of digital technologies such as BIM.

The UK has the potential to lead one of the defining developments of the 21st century, which will enable the country to capture not only all of the inherent value in our built assets, but also the data to create a digital and smart city economy to transform the lives of all.

This strategy represents the outcomes and recommendations for the next stage of the Building Information Modelling journey. We have enjoyed dramatic success in the UK with the Level 2 programme, taking a significant part in the recorded savings of £840M this year for construction spend and much international profile. This work will carry on through 2016, but if we are to remain at the forefront of this market and make the best possible opportunities for growth and jobs for the future, as well as face the challenges of continued globalisation and urbanisation we must continue to challenge the existing models and invest in our shared digital future.

We would like to thank and commend the public and private sector organisations that have engaged so effectively in this strategy to date.

Sir David Higgins

Chairman – High Speed 2

Industry Co-Chair – Construction Leadership Council

Mark Bew MBE

Chairman - UK BIM Task Group

3. Executive Summary

The next stage in the digital revolution has begun. Having transformed retailing, publishing, travel and financial services, digital technology is changing the way we plan, build, maintain and use our social and economic infrastructure.

Building Information Modelling (BIM) is changing the UK construction industry – a vitally important sector that employs more than three million people and in 2010 delivered £107billion to the UK economy. Over the next decade this technology will combine with the internet of things (providing sensors and other information), advanced data analytics and the digital economy to enable us to plan new infrastructure more effectively, build it at lower cost and operate and maintain it more efficiently. Above all, it will enable citizens to make better use of the infrastructure we already have. This is Digital Built Britain (DBB).

BIM uses advanced computer systems to build 3D models of infrastructure and hold large amounts of information about its design, operation and current condition. At the planning stage it enables designers, owners and users to work together to produce the best possible designs and to test them in the computer before they are built. In construction it enables engineers, contractors and suppliers to integrate complex components cutting out waste and reducing the risk of errors. In operation it provides customers with real-time information about available services and maintainers with accurate assessments of the condition of assets.

In 2011 the Government Construction Strategy mandated the use of Level 2 BIM on all public sector projects by 2016. This bold decision has led to Government and the construction industry working together to develop the industry's skills and reduce the cost of infrastructure. BIM has been identified as a significant contributor to the savings of £804m in construction costs in 2013/14 recently announced by the Cabinet Office. The Ministry of Justice has identified BIM as having enabled £800,000 of savings in the development of the Cookham Wood Young Offenders Institution. And this innovative technology is central to the development of new rail projects like Crossrail and HS2 where it is confirming the UK's leading role in the development of digital technologies for infrastructure and construction.

This Digital Built Britain strategy takes the next step in integrating these technologies, transforming our approaches to infrastructure development and construction and consolidating the UK's position as a world leader in these sectors. We want to make fully computerized construction the norm and ensure that the benefits of these technologies are felt across the UK and support the export of these technologies and the services based on them. We want to sell our expertise and our cutting edge technologies across the world and seize a share of the $15trillion global construction market forecast by 2025.

A new round of investment in these technologies and the skills that support them will enable us to continue and extend the work that began in 2011.

The funding will be used for a series of key measures including:

- The creation of a set of new, international 'Open Data' standards which would pave the way for easy sharing of data across the entire market

- The establishment of a new contractual framework for projects which have been procured with BIM to ensure consistency, avoid confusion and encourage, open, collaborative working.
- The creation of a cultural environment which is co-operative, seeks to learn and share
- Training the public sector client in the use of BIM techniques such as, data requirements, operational methods and contractual processes
- Driving domestic and international growth and jobs in technology and construction

But if the opportunity is great, so too is the risk of not acting now, building on our existing programme and capitalising on our global position. The pressure on finite resources, the need to generate more capacity and provide more services for less money, the need to facilitate dramatically better use of our current and future built assets and the need to retain our pole position on the global stage – all of these mean we simply cannot afford to fall back in the BIM arms race.

With Digital Built Britain in place the revolution can continue apace and we will stand more than ready to meet the challenges of urbanisation and globalisation that the UK faces.

"BIM is the first truly global digital construction technology and will soon be deployed in every country in the world. It is a 'game changer' and we need to recognise that it is here to stay - but in common with all innovation this presents both risk and opportunity.

The UK programme based on the BIS BIM Strategy is currently the most ambitious and advanced centrally driven programme in the world. The UK has a window of opportunity to capitalise on the success of its domestic programme and to take on a global leadership role in BIM exploitation, BIM service provision and BIM standards development. In taking on the role it will greatly enhance the global image of UK designers, contractors and product manufactures which in turn will translate into winning new work, growth opportunities and increased employment.

The comprehensive scope and integrated structure of the current UK programme is also an ideal platform on which to take BIM to the next logical level and aim for a fully integrated BIM - which will bring untold benefits.

The UK has displayed a high degree of courage to embark on the current programme and I, for one would urge that they continue to press ahead on the global stage together with their ambitions to develop BIM to the next level. It is often said that 'fortune favours the bold' and this will have resonance with this endeavour."

Patrick MacLeamy

Chief Executive Officer - HOK Architects

Chairman - buildingSMART International

4. Introduction, Context and Outlook

Securing the Future of the UK Construction Industry

The UK Construction industry indirectly employs over three million people. It is highly diverse with a range of discrete sub-sectors, which delivered around £69Bn GVA (£107Bn output) to the UK economy in 2010. It is a key contributor to UK growth with the global construction market forecast to grow by over 70% by 2025. It has a critical role in meeting the UK climate change targets. In addition, the UK has a large and growing Facility/Asset Management sector ensuring that built assets are operated effectively and efficiently.

The UK has a comparative advantage in several sectors, primarily engineering, architecture and the activities involved with creating low carbon environments. Over the past two years as part of the 2011 Government Construction Strategy (now fully embraced by the Industrial Strategy for Construction, Construction 2025) the UK has taken a world lead in the adoption of digital technologies with the delivery of the Level 2 Building Information Modelling (BIM) programme, recognised by the award of the International Fiatech Innovation Award in 2013.

The delivery of the Level 2 BIM programme has enabled us to help secure 20% savings on CAPEX as recorded by Cabinet Office case studies against the 09/10 benchmarks, helping to create mass awareness of the need for and techniques required to deliver a digital construction economy. This has been achieved in parallel with the emergence of the Smart Cities Agenda, which identifies a global market of around £400B by 2020 for services related to smart systems for transport, energy, health care, water and waste. Further to this we have seen the publication of the Information Economy strategy which has set out to create an open secure environment for the development of the technology market, together with encouragement to use High Performance Computing (HPC), complex analysis and the Internet of Things (IoT) in the form of automated sensors and actuators to automate processes.

The convergence of these three opportunities has led to a unique position; we now have the understanding as to how technology can transform both our lives and the world we live in. The development of this Level 3 Strategy, which will be known as “Digital Built Britain” (DBB), will encompass the cross sector collaboration and thinking described above whilst taking the opportunity to rethink how we procure, deliver and operate our built environment going forward to ensure we meet our fiscal, functional, sustainability and growth objectives.

The Challenge

In the UK, as in many developed economies, our social and economic infrastructure is mature and in need of extensive maintenance, renewal and modification to meet emerging needs. Our facilities and networks are becoming ever more integrated, to the point where their reliability often determines their capacity, stifling economic growth and social wellbeing. In the aftermath of the financial crisis of 2008, H M Government has limited resources to spend on new infrastructure. When new projects are proposed there is invariably opposition to them because of their impact on the environment and the disruption they cause.

Repeated reviews of construction industry performance going back to the Banwell Report of 1964[5] have shown that the UK’s transactional, tactical approach to designing and building infrastructure is sub-optimal. Instances of sustained cost inflation and market volatility experienced during periods

of growth demonstrate that compared to many other capital delivery industries, construction remains inefficient. As such it is failing to support investment in the UK companies that provide the components and technologies that enable us to develop and use our infrastructure effectively. In 2010 HM Treasury's Infrastructure Cost Review[6] demonstrated that the capital cost of building roads, railways and other economic infrastructure is as much as 40% more in the UK than in comparable European economies. The investigation into the procurement of rolling stock for Thameslink[7] showed that little consideration had been given to sustaining UK-based industries that are needed to service our infrastructure in the long term.

Sustainable economic growth, pressure on resources and the emergence of the "Digital Economy" present HM Government with the following key challenges associated with 21st Century infrastructure

- ***Providing more with less*** – we have to find ways of delivering more capacity and better public services from our economic and social infrastructure with less capital investment. This means using modern technologies to get more capacity out of our existing infrastructure.
- ***Maximising availability*** – we have to find ways of maximising the time that facilities and networks are available to be used by the public. This means using modern technologies to continuously monitor the condition and operation of infrastructure and to intervene before problems arise and to develop better solutions for the future.
- ***Reducing Cost and Carbon (Whole Life)*** – HM Government has consistently pointed to the need for new business models and integrated supply chains to deliver engineering and construction services more efficiently, but this requires the development of new organisations, new skills and new systems to support the new ways of working.
- ***Enabling Significant Domestic and International Growth –*** We must support UK businesses at all levels of the supply chain to broaden and diversify their domestic and global customer base.
- ***Ensuring that the UK remains in the international vanguard*** – We must develop, deploy and capitalise on the Digital Economy in the area of social services and the built environment to maximise our profile and market opportunity.

Our current approach to designing and procuring infrastructure and assets not only adds significantly to transaction and delivery costs, but also creates artificial scarcities of key services, resources and components through duplication of activity. The most obvious example of this is in the design of projects where scarce professional services are often used to do detailed design work that is often repeated by suppliers and would more properly be done by those suppliers in the first place. These scarce professional service skills could be better used in early stage design targeted at export markets.

The common practice of dividing projects up into trade packages for procurement also creates scarcity by excluding many companies that could bid to supply components but do not have the skills to supply all of the other services defined in the specific package. Greater use of component-based design and manufacture enabled by standard product libraries with embedded performance, cost and carbon data has the potential to address this limitation on the supply chain.

Traditional methods also follow a linear process with clients identifying needs and formulating a brief, passing through design, procurement, delivery and operations. There is no feedback loop to optimise performance or to evaluate changes of use. With the potential of the "Internet of Things"

to capture in-use performance data, we anticipate that these processes will change. In service performance data will transform the way we manage and deliver our assets.

The vision of the Digital Built Britain strategy creates the opportunity to disrupt the current approach to designing and procuring infrastructure projects by:

- Providing a platform through which a wide range of suppliers (including SME's) and other stakeholders can be engaged in finding the best informed lifecycle solutions to infrastructure problems and in them being in a position to bid to supply solutions;
- Improving technical solutions and reducing costs by challenging the existing roles of consultants, contractors and suppliers;
- Developing new business models for infrastructure and asset design, delivery, operation and adaptation, based on wider use of service performance data;
- Protecting national security, we must ensure that in increasing the availability of data, we put in place or build into design of any BIM project and its ongoing management, security measures and protocols such that threats may be deterred, detected, or the consequences of an attack minimised

What is Building Information Modelling?

Building Information Modelling (BIM) is a collaborative way of working, underpinned by the digital technologies which unlock more efficient methods of designing, delivering and maintaining physical built assets. BIM embeds key product and asset data in a 3D computer model that can be used for effective management of information throughout an assets lifecycle – from earliest concept through to operation. BIM has been described as a game-changing Information and Communications Technology (ICT) and cultural process for the construction sector. A number of countries globally are starting to realise the opportunities it brings and are now investing heavily to develop their own capability. BIM processes are now main-stream to both new buildings and infrastructure and have great value in retrofit and refurbishment projects where complimentary technologies such as laser survey techniques and rapid energy analysis are employed.

Current Situation

Over the past two years as part of the 2011 Government Construction Strategy[8] (now fully embraced by the Industrial Strategy for Construction - Construction 2025[1]) the UK has taken a world lead in the adoption of digital technologies with the delivery of the Level 2 Building Information Modelling (BIM) programme, recognised by the award of the International Fiatech Innovation Award in 2013. The delivery of the Level 2 BIM programme has enabled us to help secure 20% savings on CAPEX as recorded by Cabinet Office case studies against the 09/10 benchmarks[9], during a period of focused and sustained departmental savings and create widespread awareness of the need and techniques required to deliver a digital construction economy.

Context

Digital Built Britain is designed to enable H M Government and all related industries to respond to these challenges and create a market that not only delivers world class public sector services, but enables the private sector to deliver value and capability worldwide, by enabling new processes, relationships, transparency and performance insights across the entire asset lifecycle. Information exchanges enabled by the strategy will align bottom up asset detail from BIM and Asset Management and with development in the wider Information Economy associated with High

Performance Computing and the Internet of Things - providing a solid platform for construction and asset management industry reform and the enabling of the Smart City and Smart Connected Citizen vision of the future.

Construction industry reform has been led in the past by many including Latham[10], Egan[11] and Wolstenholme[12]. However these laudable, iterative approaches to industry reform lacked the compelling transformational forces of transparency and feedback made possible through technology. The transformational opportunities demonstrated through the Level 2 BIM programme will allow us for the first time to fully align supply chains engaged in the delivery of new infrastructure and assets with the people responsible for operating and maintaining the assets – creating for the first time an integrated model of asset creation and operation. In particular, the ability to measure "in service" performance and to make outcomes a fundamental part of the procurement model will enable users to focus on actual measured performance and the implications of both their business performance as well as the network and individual assets.

Outlook

The construction and Facilities Management (FM) industries each represent a significant share of national GDP and are known to have significant potential for performance improvement. Collectively, the two sectors are responsible for the creation and utilisation of a large share of wealth, which in turn drives the wider economy[13].

According to the Office of National Statistics, UK construction output totalled £121.7Bn in 2013[14]; with direct public sector spend on housing, infrastructure and other construction totalling £20.1 Bn. Expenditure through the contracting industry supply chain, excluding house building and repair and maintenance totalled £52.5Bn. With construction activity returning to growth during 2013, it is forecast by the Construction Products Association[15] that activity levels will grow by 4.3% per annum (CAGR).

Based on an analysis of supply chain costs undertaken by EC Harris on behalf of BIS in 2013[16] , the proportion of spend that can be attributed to on-costs and overhead and profit within the contracting industry supply chain ranges from 17% to 20%. Based on the output of the contracting industry there is a £10Bn per annum opportunity to improve the profitability or to reduce the cost base of the UK industry alone.

According to the Global Construction 2025 Report, quoted in the 2025 Construction Industrial Strategy[1], the global construction market was worth $8.7Tn (£5.1Tn). This is forecasted to grow to $15Tn by 2025, with much of the growth taking place in locations in Asia and EMEA where the UK has an active export presence in professional services.

High levels of construction investment are expected to make a substantial contribution to the growth in the value of the stock of Built Asset Wealth. According to research published by CEBR[17] and EC Harris[18] in 2013 and 2014, the combined stock of built asset wealth in the 30 largest economies totalled $193Tn in 2012 (£114Tn). This is forecast to grow by 35% in real terms by 2022, to total $261Tn. The research also shows that 30-40% of GDP can be attributed to activity supported by Built Asset Wealth. Future growth will create new challenges in connection with the optimisation of the utilisation of assets and the costs of their operation and maintenance – creating huge opportunities for business models focused on asset optimisation.

The UK Operations and FM Industry is equally large and influential – with an output of £106.3Bn in 2013 according to MCi[19], which is forecast to grow by 2% pa to 2017. Other markets which will create opportunities around the exploitation of built asset data resources include the Smart Cities agenda and the wider market for data analytics and big data.

The UK Department for Business Innovation and Skills (BIS) estimates that the global market for integrated citywide solutions is £200Bn[20] a year. Opportunities for knowledge transfer between countries and continents are also significant; there are well over 1,000 cities in the world with populations in excess of 500,000. The UK, through partnerships with other world cities and research organisations, has the opportunity to lead in this space. Training experts to address these problems requires major and co-ordinated commitment from a large, international group of experts: domain experts from cities who can present the challenges; analytical experts to give the tools to understand them; computational experts to help scale the solutions to large-scale datasets; policy experts to address the impact of change; industry experts to implement solutions.

The data analytics market is forecasted to grow by industry forecaster IDC to reach $16.1 Bn[21] (£9.5Bn) and achieving a 50% CAGR between 2013 and 2017.

The big data trend will affect all industry sectors over time. The Digital Built Britain strategy takes the momentum created by Level 2 work to accelerate benefits realisation in the construction and asset management sector.

"Almost every information business that the internet touches, the first thing it does is it rips the guts out of the scarcity model."

"The new companies don't take the profits of the old companies; they make the profits of the old companies go away."

Clay Shirky, New York University

5. The Vision

The Built Environment as part of a Smart, networked world

The Built Environment has a dramatic impact on all of our lives. We all live, work and play in a world that we have physically created and our ability to respond to the challenges of the future requires us to re-look at how we define, deliver and operate our Built Environment.

The Information Economy Strategy[24] identifies that our most pressing societal challenges manifest themselves in our cities. Rapid urbanisation is a critical issue in emerging markets, where the growing middle class is demanding cleaner, more sustainable and healthier urban environments, with reliable sources of energy and less congestion. City leaders around the world are turning to integrated and intelligent smart systems and associated big-data concepts to deliver vital public services, including:

- Healthcare and assisted living, patient monitoring, digital records and administration
- Smart Energy Grids, demand management and renewable source integration
- Transport, traffic and congestion management, road charging, emergency response, public information, managed motorways and smart parking
- Water management, consumption measurement, wastewater treatment
- Waste management, collection and processing of all types of waste including carbon

These opportunities are at the heart of the UK Government's Smart Cities Strategy which identifies that UK firms are at the forefront of this area. Bringing together expertise in design, planning, construction, operations, funding, technology and risk management will enable the UK to capitalise on the essential need to provide infrastructure and its services to our citizens and across the world.

The Level 3 vision as part of a wider digital strategy

This Digital Built Britain Strategy brings together The Industrial Strategy – Construction 2025, the Business and Professional Services Strategy[22], the Smart Cities Strategy[23] and the Information Economy Strategy[24] to provide a consistent vision as to how we can create a high performing, transparent economy that efficiently delivers services to all of its citizens. The vision for Digital Built Britain is to provide a seamless transition from the achievements of Level 2 BIM and the Construction Strategy in to an environment where technology and working with technology is second nature in construction. This will enable a thriving UK Digital Economy for the Built Environment, encouraging growth and competitiveness and facilitating dramatically better use of current and future built assets with:

- A strong, innovative construction, operations and information economy sector exporting UK excellence to the world using new models of delivery and engagement
- UK businesses and organisations, especially small and medium sized enterprises (SME's) confidently using technology, able to trade online, seizing technological opportunities and increasing revenues in domestic and international markets
- Citizens and stakeholders with the capability and confidence to make the most of the opportunities these technologies provide

The long term success of the strategy will be underpinned by

- A skilled digitally enabled workforce - including both specialists who create and develop these technologies and services and the construction and asset management generalists who use the technologies
- The digital infrastructure (both physical and regulatory) and the framework for cyber security, regulation, contracts and privacy necessary to support trust, growth, collaboration, innovation and excellence
- A rich data set describing the existing user and asset base, supporting the development of new service opportunities and markets
- Sharing of technologies across many sectors to increase investment, value and collaboration across the market
- An effective education and change management programme to enable the industry to develop necessary skills and new ways of working

The Opportunities Addressed by the Vision of Digital Built Britain

Delivery of the transformation required to enable a Smart connected high performing built environment is a long-term project. In line with the Level 2 BIM strategy of 2011 we will continue the approach by taking progressive steps. The progress made with Level 2 is detailed at www.bimtaskgroup.org It has defined new working methods and has created new controls for procuring, validating and processing standard open data. The impact of Level 2 has been based on exchanging data and already industry and clients are setting further challenges including:

- How we can make this exchange faster and more efficient?
- How can we simplify the process by including geometry and data in the same data package?
- How can the data exchange be made on the web across the world, in any language?
- What can we do with the data generated by the Internet of Things, to improve asset performance?

Our migration to Digital Built Britain must answer these questions, but also help the industry to maintain the significant productivity improvements - including more savings of up to 33% of whole life costs starting with the circa 20% reduction in capital costs that have been achieved using BIM at Level 2[25].

New Business Models Enabled by Digital Built Britain

The potential for new technologies to deliver business transformation has been demonstrated in many industries; however the built environment has been slow to adopt these technologies and remains one of the last major industrial sectors to adopt new ways of working.

The Level 2 BIM programme has however very publicly demonstrated across the world that the UK can lead challenging engineering change programmes and as more new technologies become affordable and the challenges of providing low-cost, low-carbon services become more acute we must grasp the opportunities created by these technologies:

- The ability to measure “in service” performance and compare it to “as briefed” and “as delivered” assets - providing the single biggest opportunity to improve both cost and carbon performance.
- The ability to bring together through open data standards from design, construction and operations and across market sectors - offering the ability to analyse and create the learning

feedback loops that industry needs to be able to deliver sustainable long-term improvements in asset performance.

Figure 1 indicates the methods by which we expect to see these processes evolve under Level 3. As can be seen there are three predominant datasets portrayed as blue pyramids. These hold data from the operational, delivery and performance management phases of a portfolio, programme or project. The further up the pyramid data progresses, the more the strategic its use becomes starting with full atomic asset detail, through organisational portfolio use to Smart City and strategic planning purposes such as investors or HM Treasury. Digital Built Britain will be based on the Level 2 "data exchange" process but this will be enhanced by more extensive data definitions and processes including Model Views which will allow interoperable sharing of information at key stages. This will also be extended across market sectors to enable the cross asset view of a Smart City or Smart Grid.

Under the Digital Built Britain vision, data developed through the delivery, operational and performance phases contained in these data stores will be selectively published through data.gov and other secure gateways as Open data for further market use. It is anticipated that in the future more data about people and social issues will become available. The opportunity to integrate this data is included in figure 4. These concepts will form the basis for Level 4 BIM with a clear focus on social outcomes and wellbeing.

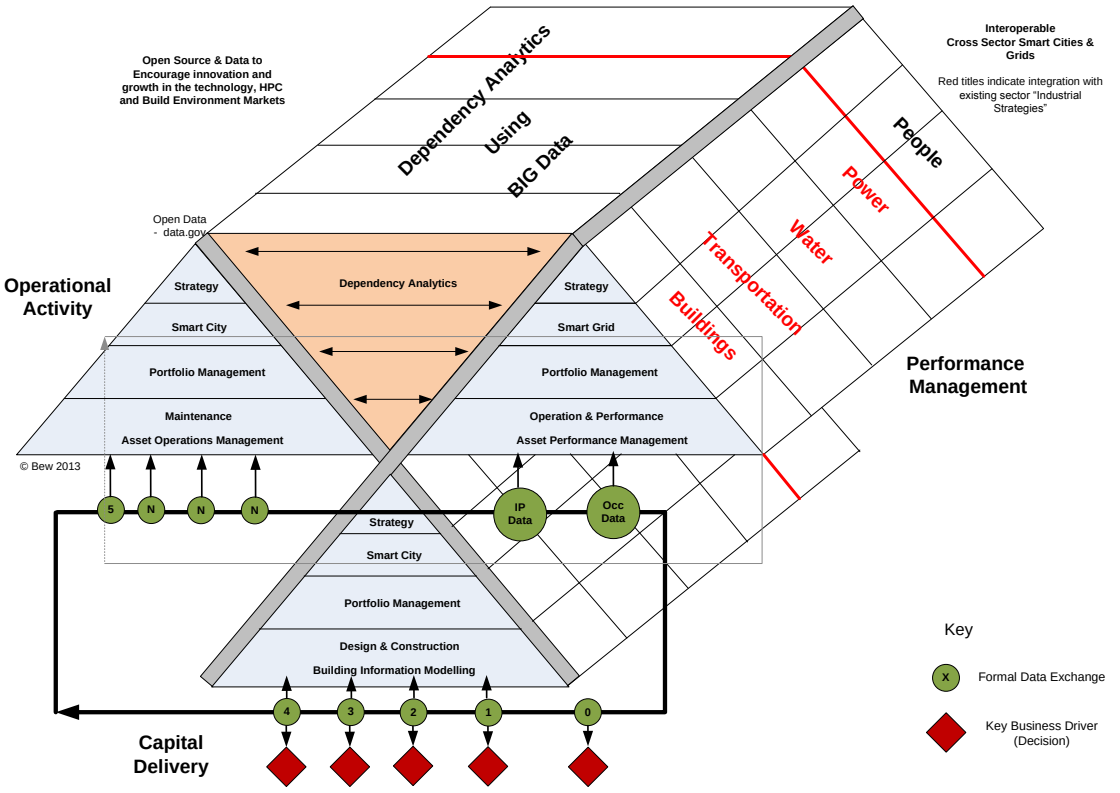

Figure 1 Digital Built Britain Operational Model

This Open data source provides a rich "operational analytics" market place as indicated in the orange area of the model. Examples of this include the TfL Oyster Card system, but also other market specific analytics such as product and factory automation as exampled by the Laing O'Rourke[26] and its integrated Digital Engineering approach (See panel on page 19).

A significant number of software vendors have taken part or shown interest in the development of this strategy and have agreed to the principle of a sector incubator programme to accelerate the adoption of analytic technologies to help enable the development of much improved products, materials and service to the industry, this is described further in section 7f.

Creating an Industry Focus on Performance

Recent work in connection with the Government Soft Landings (GSL) initiative[27] has highlighted that commercial mechanisms are not currently able to facilitate a greater focus on the absolute achievement of performance requirements. The involvement of multiple parties employed on a skill and care basis makes it currently difficult to enforce performance requirements. This is a partial explanation of the widely observed 'performance gap' in buildings and is a key driver behind the introduction of GSL. In considering the disruptive change associated with Digital Built Britain - Level 3 targets it will be necessary to identify opportunities which address the polarisation of transactions in construction markets between:

- Assets which are acquired through a transaction – in particular, transactions that could be managed or effected through the exchange of data
- Assets which are acquired with reference to performance measures – where data could facilitate the transaction.
- Suppliers who are paid on the basis of deliveries and performance, through open transparent banking and payment solutions
- The role of the commercial manager is developed to be a lifecycle role to optimise commercial and operational performance

nest

"We're about creating the conscious home"

Nest CEO - Tony Fadell

What the Future Will Look Like Under Digital Built Britain?

Under this strategy, Digital Built Britain will enable asset owners to use technologies and techniques to create transparent collaborative relationships with their suppliers. The teams enabled by Digital Built Britain will be encouraged to co-operate in developing solutions to problems which will be digitally prototyped ahead of a commitment to significant capital expenditure. Digitally enabled collaborative working offers the platform for the sector to develop new businesses around the new technologies based on opportunities around the full asset life-cycle – new businesses that could then offer the solutions to other infrastructure companies in the UK and overseas to enable dramatic growth. The potential scope of these solutions and nascent business is vast and those that we are aware of today would include:

- Data-enabled collaborative working in the design, construction and operation of assets enabling best use of capability in the supply chain to deliver value to customers
- Use of data recording asset operation and condition to understand asset performance, define better project briefs and to form the basis of new performance contracting models

- Application of remote monitoring, telemetry and control systems to the real time operation of assets and networks
- Integration of infrastructure with control systems such as in cars or trains to maintain positions in lane and distances between vehicles thereby reducing the risk of collisions and increasing the capacity of networks.
- Use of 3D printing and other local fabrication techniques to provide components for infrastructure projects as well as Smart factory automation and DfMA (see figure 4)
- The enabling of the Internet of Services (and Construction) as well as associated value chains, to allow cross sector collaboration
- Use of embedded sensors and other features of the Internet of Things to monitor the condition of infrastructure and predict the need for maintenance interventions, creating a feedback loop back to the asset brief, enabling the opportunity to invoke performance contracts and reporting
- The availability of performance data at sources such as data.gov to enable a vibrant and growing digital analytics and services sector. This is exampled by the TfL Oyster Card system and the services developed by TfL and KPMG and the deployment of technology on motorways to provide Smart capabilities by the Highways Agency[28].

"Companies must know everything they can about how they are consuming energy before they can decide what to do about conserving energy."

Accenture 2013

Using 3D printing and scanning methods could notably drop the costs. Sellafield has already used the technique of additive manufacturing to reproduce a new lid for a 40 ton Solid Waste Export Flask, and the financial results are immense. Normally, reproducing this rare lid would have cost about 25,000 pounds, but using 3D scanning techniques dropped the costs to a total price of 3,000 pounds.

In a statement, **Sellafield's Head of Metrology** - **Alistair Norwood** states: "We're seeing huge numbers of possibilities where we don't have to redesign work."

Stakeholder View

With a wide diversity of stakeholders it is important to consider the impacts and benefits; these should be considered in the context of the effect that technological, commercial and requirement change will influence both the demand and supply side of the construction industry. This socio-technological effect was described by Tom Peters and the McKinsey 7S model[29] long ago but the relationship between hard business elements such as structure, strategy and systems will challenge and create significant opportunity with the softer socio issues such as shared values, skills, staff and style. The models in figure 2 indicate an industry scale of how the impact of new technology, ways of doing things and business models indicated on the left hand diagram may manifest as industry related outcomes on the right hand diagram. The resultant new ways of thinking will enable the transition to a more effective service orientated and outcomes based industry, defined by more efficient and effective service organisations.

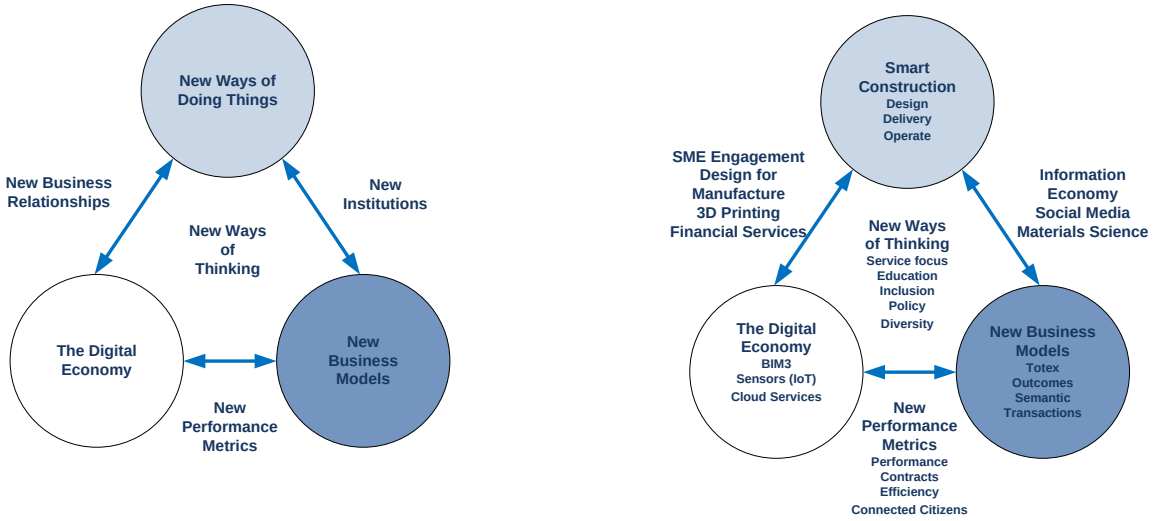

Figure 2 – Business Change Model

> "Rolls-Royce now earns more from tasks such as managing clients' procurement strategies and maintaining aerospace engines it sells than it does from making them."
>
> **The Economist**

"Rapid advances in digital engineering are revolutionising construction. But Building Information Modelling (BIM) is about more than creating models. It is about unlocking knowledge and insight, creating the platform for more efficient and sustainable solutions. At Laing O'Rourke we're taking BIM beyond the traditional geometrical and asset data approach to include time and cost dimensions, offering unparalleled benefits to clients and end-users over the lifetime of buildings and infrastructure.

Critical to our innovative Design for Manufacture and Assembly (DfMA) approach, BIM is helping to drive a step-change in the increased productivity of the construction process, tangible quality improvements in the end product and the associated reduction in true costs. It promotes greater collaboration and more informed decision-making within unified delivery teams, while allowing the supply chain to see beyond their own activities to a more holistic view of the client's objectives. Equally important, BIM also acts as a valuable communication tool by bringing the project to life in a virtual world for clients and the workforce.

Fundamental to achieving success is having the right blend of technical and cultural platforms. Laing O'Rourke is realising this through extensive training of forward-thinking engineering and construction leaders to embed BIM and DFMA across our culture. At the same time, delivery teams – both on-site in our projects and off-site in our Manufacturing facilities – are driving BIM into core business processes. This de-risking enables us to innovate for the benefit of clients, maximising the value of the asset over its lifetime.

We are determined to use the momentum around BIM-enabled DfMA to effect an innovative and radical transformation of our industry, helping to create exciting new career opportunities to attract the next generation of engineering and construction talent. I firmly believe that through BIM and DfMA the industry will become more integrated and productive at every stage of delivery - from design to construction and, ultimately, in operation. It is 'challenge and change' at its most visionary."

Ray O'Rourke KBE, Chairman, Laing O'Rourke

The availability of in service performance data on a wide scale will also enable smarter decisions to be made by clients and operators at all levels. The continual balance between need and budget, opex and capex cease to be based solely on opinion and perception, but by need and citizen satisfaction. This capability, enabled by the efficiency savings of the construction industry will provide clients of all types from infrastructure operators, smart cities, local authorities and commercial developers with data to enable analytics to demonstrate optimal maintenance and operations schemes, investment opportunities and to start to demonstrate to the connected citizen how their taxes are invested in delivering key social services. This level of transparency would provide much more focused information in the demand pipeline allowing more businesses the confidence in investing in new approaches, technology and people to meet the demand as indicated in figure 3. This transparent process would also encourage new forms of more effective governance and control based on performance and outcomes.

Figure 3 – Transparent Investment Model

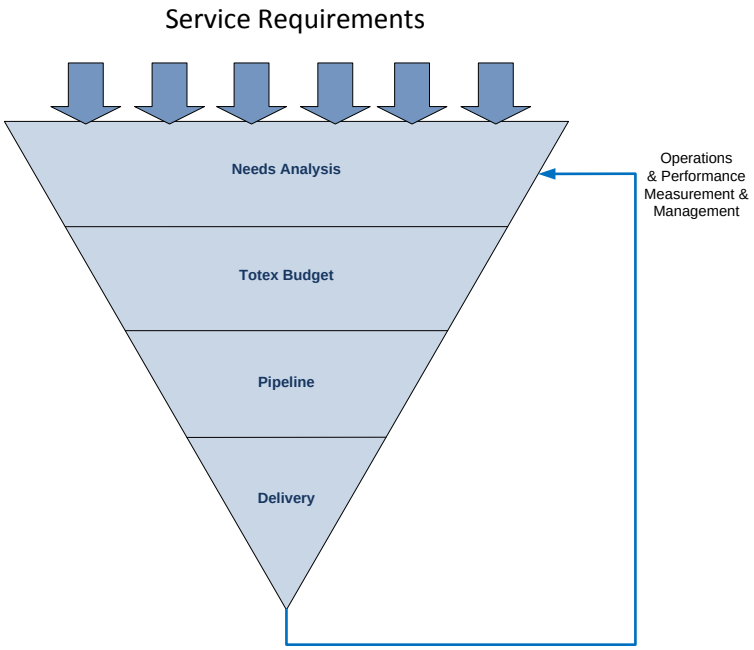

Figure 4 – 3D Printed Bracket Components

6. Actions

During the early part of 2014 a large number of industry stakeholders took part in workshops, interviews and activities (see section 9 Acknowledgements) to determine the scope and delivery approach for the Digital Built Britain programme. Four teams were convened to provide expert domain analysis in the following areas: Market Potential, Commercial, Technical and Cultural. These working groups collaborated with colleagues from other sectors and delivered their findings which are described in this document. Key Actions identified during this process are identified below.

a. Delivery Mechanisms

It is very difficult to quantify all the market opportunities that could be created by developing and deploying Digital Built Britain in the UK infrastructure and construction sector. But it is important to define the scale of these opportunities to justify the proposed investment in Digital Built Britain. It is equally important to consider the consequences of not deploying Digital Built Britain and thus delaying change in these important industries and allowing them to fall further behind their international competitors.

Given the breadth of the Digital Built Britain strategy, including asset operation and asset performance, it is clear that the market opportunities that arise from deploying Digital Built Britain will not arrive all at the same time. In the first instance Digital Built Britain will be deployed within sectors using the existing business models as an extension of Level 2 BIM. In construction this will encourage more collaborative working and in Asset Management/Facilities Management, the adoption of BIM-derived information for the first time will unlock significant savings and knowledge insight.

However, as Digital Built Britain facilitates collaboration in the development of assets and infrastructure, new opportunities will be enabled for suppliers to offer new technologies and new ways of using information to facilitate access to infrastructure. In time new business models will emerge, transforming the structure of the construction industry, creating the need for new skills and substantially reducing costs. This will lead to the continued transformation of the infrastructure and construction delivery, operation and associated supply chains to lead the UK into developing new markets overseas based on the new skills and technologies. With this process in mind, it is helpful to define the scale of the market opportunities around delivery phases.

- Level 3 A Enabling improvements in the Level 2 model
- Level 3B Enabling new technologies and systems
- Level 3C Enabling the development of new business models
- Level 3D Capitalising on world leadership

The key technical and commercial activities for these stages are illustrated in figure 5.

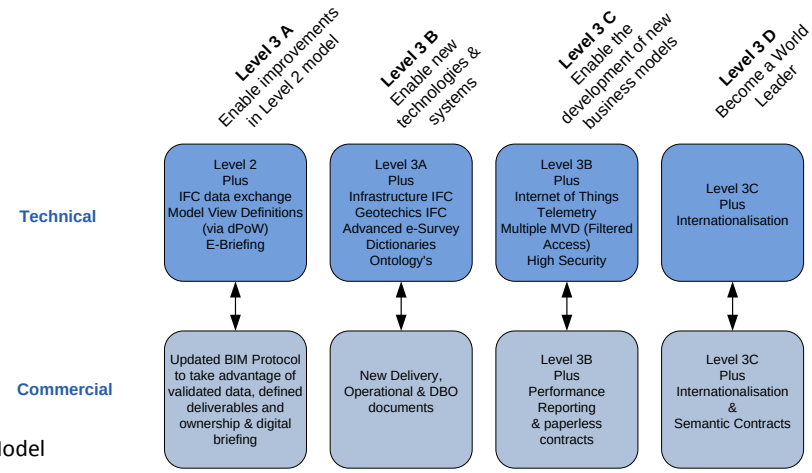

Figure 5 – Delivery Model

The focus for the delivery programme would follow the successful formula developed for Level 2, where a core team would co-ordinate under the governance of a Steering Group the delivery of funded work packages focusing upon

1. Departmental (public client) engagement and early adopter programmes

   Development of the existing structures of Level 2 with engagement through the BIM and GSL Stewardship Groups with Governance provided by the Government Construction Board, E-Infrastructure Leadership Council and funding bodies.

2. Processes, Standards and supporting services

   Project management of the technical, commercial and processes documentation and standards in collaboration with British Standards Institute, Building Smart and the Ordinance Survey, through the procurement and management of work packages

3. Market engagement

   Development of the existing Level 2 communication and BIM4Hubs programme, with a greater focus on wider engagement of SME and regional businesses

The delivery programme would be managed by a Programme Management Office which would work with key partners to provide capability and support to the programme. These organisations would include Institutional Bodies, British Standards, Building Smart International and Ordinance Survey.

Actions – Delivery

1. Create a Project Management Office to host and deliver the Digital Built Britain – Level 3 programme
2. Convene a Steering Group, governance, support and delivery structure
3. Deliver the communications strategy, including website, Twitter and BIM4Groups
4. Deliver a programme of work streams and actions
5. Maintain the risk and opportunities management process
6. Continue to liaise with the Level 2 legacy team to ensure lessons are learnt and carried forward
7. Co-ordinate with the EU and international growth teams to ensure continuity
8. Co-ordinate with Cabinet Office and individual departments to progress from Level 2 to DBB Level 3

b. Commercial

Changes to existing commercial models will be required to deliver the opportunities for performance improvement identified under the Digital Built Britain strategy:

- Closing the loop between performance and the creation and adaptation of assets. Contracts will focus on the capture of performance intelligence and project feedback and the deployment of a data-based briefing process
- Alignment of the construction, facilities and asset management industries with developments in other elements of the economy including big data and telemetry. Commercial models will address structural constraints such as incentives to create data assets that currently limit the ability of these industries to collaborate effectively
- Alignment of the interests of the construction supply chain. Collaborative models of working, facilitated by data will permit greater engagement with lower tier suppliers. New commercial models will address causes of sub-optimal performance including;
    - Definition of optimised project roles and desired behaviours, together with the contribution and position of lower tiers of the supply chain
    - Reward, payment and cash flow through construction supply chains
    - Elimination of all forms of waste, including costs of transactions
- Increased maturity in the use and management of existing assets. Over 90% of assets that will be in use over the next 25 years already exist. Commercial models based on 'Totex delivery' are needed. Growing knowledge of the extent, condition and utilisation of existing assets enabled by technology will accelerate the move to wider adoption of the 'Totex' approach to expenditure management.
- Introduction of new sources of capability and competition into the industry. Main contractors act as integrators of resources and conduits for risk transfer, focused primarily on the creation of new assets. As greater attention is placed on the operation of existing assets, commercial models should be developed to attract new capacity, such as:
    - International contractors attracted by opportunities around the performance contracting model
    - Technology businesses attracted by the opportunities driving value through data and collaboration.
- Securing the benefits of transparency in transactions. Construction and asset management are characterised by low levels of commercial transparency, including limited access to pricing and payment information within the tiers of the supply chain. Increased transparency enabled by new commercial models could be a significant source of disruptive change – driving a wider rebalancing of commercial interests between the client and the supply chain, and within the supply chain itself. Transparency will be supported through the assurance of the provenance of data supported by technology and standards – enabling all parties to be able to rely on data sourced from others.
- Enabling transactions based on performance analytics. Commercial applications based on the use of "big data" derived from the web will require new forms of contract to establish commercial models for "semantic" transactions and their associated benefits, obligations and liabilities. Provenance solutions will also underpin these semantic transactions.
- Creation of barriers to entry from increased competition in construction delivery. Increasing barriers to entry based on differentiation secured from fully integrated supply chains and value-added capability in data asset creation

- Understanding of the regulatory framework, especially planning, building control and health and safety as key processes that require digitisation.

Actions – Commercial

1. Level 3 A (Enabling Improvements in the Level 2 Model)
    a. Improve Level 2 from lessons learnt – including more effective data exchange and data-enabled collaborative working based on transactional contracts
    b. New protocol to address certainty associated with asset performance – including validated data and digital briefing, building on the foundations of Government Soft Landings
    c. Build new E-Briefing Methods using new data capabilities (IFC and MVD) – enabling the electronic testing of compliance with business requirements
    d. Development of BIM and asset data enabled FM and AM Contracts – including the FM and AM roles in using and maintaining BIM models
    e. Insurance – supporting wider adoption of integrated project team insurance models
    f. Development work associated with data rights, use of data to support performance contracts, use of data associated with existing assets, Totex contracts, carbon performance etc.
2. Level 3 B (Enable new technologies and systems)
    a. Extend the scope of data exchange – including contract changes to support the adoption of upgraded IFC-based data, digital dictionaries etc.
    b. Create new incentives for data capture and the wider utilisation of project and programme data across the asset lifecycle
    c. Target new contracts and commercial models to encourage new market entrants and the development of valuable, exportable skills and capabilities in the UK industry
    d. Development work associated with transparent, data-enabled contracts, including paper-less trading
    e. Development work associated with asset operation including Totex and the Incentivisation of asset operators to deliver enhanced infrastructure capability
    f. Development work on use of widely sourced data, digital risks and security
3. Level 3 C (Enable the development of new business models)
    a. Development of paperless contract models
    b. Development and implementation of data-enabled performance contracting
    c. Development of integrated Totex-based contracting models for new and existing infrastructure
    d. Creation of commercial models based on transactions enabled by the Internet of Things
    e. Integration of access and security control solutions into commercial arrangements including contracts and insurance
4. Level 3 D (Become a world leader)
    a. Development of international contract models for Level 3 working

c. Technical

The Digital Built Britain strategy is fundamentally enabled through the convergence of a number of technologies which have matured to the extent where industrial application is possible. The technologies involved within the BIM elements are all informed by the Level 2 BIM programme. As already discussed, the limitations of the Level 2 programme, especially in the areas of model federation and integration, combining geometry and attribute data and managing data in databases and the cloud to enable much simpler sharing and reuse are key focuses of the early delivery stages of Level 3 (L3A&B).

A key element of the technical strategy will require a close look at technologies and interfaces with users. A reoccurring theme with much engineering and especially BIM software has been the fact that it attempts to solve all user functions and in doing so becomes so complex only a small community of interested parties can actually use the systems. Normal lay users are mostly conversant with applications such as email and social media, both of which perform complex processes, yet manage to present the user with clear simple interfaces. Our aim must be to present the day to day user with useful easy to consume and interact with information and knowledge.

With an industry so keen to enable collaboration of diverse people, the uptake of social media in the supply chain has been relatively slow. Where uptake has taken place it has been with tools such as LinkedIn which have a more business focus. Lessons should be learnt from this and the patterns of social media uptake to create an appropriate toolkit to encourage very wide adoption and usage.

During the production of this strategy we have considered a vast range of issues to establish the correct approach to this fast-moving and complex arena. Our approach has been to collaborate with other sectors and providers to identify the various technical elements and identify the key areas that require strategic intervention to enable the market and other areas that either the market is working well and requires no intervention, or where work should be completed in collaboration with other sectors. Cross sector collaboration is viewed as highly desirable where we can pool resources and budget in the areas of developing non-competitive infrastructure services. These areas may include

- Cyber Security measures and protocols
- Information and Access Mobility
- Connectivity especially 5G
- Access to high power computing (HPC) and advanced analytics
- Social Media interfaces and integration
- Market ‘App Store’ to access key resources
- Storage and high speed data access
- Standard Internet of Things protocols and resilience capabilities
- Assurance of provenance

In order to create a base of international experience and to achieve rapid domestic and international approval we have worked with the British Standards Institution, Ordinance Survey and Building Smart International to develop a working agreement to create a delivery organisation. This will form the technical host organisation which would enable a consistent point of reference for the specification, procurement and delivery of all technical developments, especially standards. We expect (other than where work may already be under way) to deliver all work in the first instance in

the form of Publically Available Standards and as in the case with PAS1192:2:2013 (from the Level 2 BIM programme), then promote rapid migration to ISO status. The delivery organisation will be supported by an extended Technology Alliance made up of all key software vendors in both domestic and international markets.

Areas of sector specific technical work which have been identified as requiring significant support in development, either through discouraging proprietary formats in favour of open standards and data, or the need to ensure integration with cross sector considerations that will help accelerate Digital Built Britain to market, will include:

- Industry Foundation Classes (Data Definitions)
    - Completion of Existing Building Elements
    - Digital Briefing Standards
    - Ground Engineering Standards
    - Survey Standards
    - Creation of Infrastructure Elements
- Integration and standards supporting the Internet of Things
- Unified Modelling Language tools
    - To provide simplified technical and user data user access
- Model View Definitions
    - Levels of Detail
    - Data Views
    - Security Access
- Process Definitions
- Dictionaries and Ontologies
- Data and transaction provenance
- Geospatial specific open data considerations
- Internationalisation tools

"The understanding and endorsement of Building Information Modelling in the United Kingdom construction industry is as rapid as it is impressive. Due in large part to the inspired leadership of the Government's BIM Task Group, BIM is now key to the Construction Strategy and has catapulted UK construction to the forefront in BIM standards and adoption worldwide—the fastest such transition we have seen - supporting the UK's global industry growth ambitions. Its energetic efforts to transform itself into an efficient, integrated and collaborative supply chain through technology positions it as both a global authority in design and construction and an example of UK leadership in innovation and modern practice. In order to support the UK construction industry as it gears-up to meet the ambition of the Government's BIM programme, Autodesk is investing in the UK - in delivering the technology needed, assisting with strategy, and communication about the transformation occurring within construction."

Phillip G. Bernstein FAIA RIBA

Vice President, Autodesk Strategic Industry Relations

Actions - Technical

1. Level 3 A (Enabling Improvements in the Level 2 Model)
    a. Technical systems to enable requirements documentation and integrated working (in sector interoperability)
    b. Technical systems to enable e-Planning and e-Regs
    c. Complete the scope and package work for IFC data definitions
    d. Complete the scope and package work for MVD process definitions
    e. Update Level 2 dPoW system to support MVD process definitions
    f. Define and deliver security capability and guidance
2. Level 3 B (Enable new technologies and systems)
    a. Complete the scope and package work for UML (simple interface) definitions
    b. Define and deliver Internet of Things data and process standards
    c. Create and integrate common “apps” store capability with cross sector teams
    d. Improve electronic survey capabilities and services for existing structures above and below ground
    e. Deliver geotechnical capabilities
    f. Complete tools and controls for “infrastructure” development and operation
3. Level 3 C (Enable the development of new business models)
    a. Update Level 2 Classification system to support sematic web
    b. Data streams and telemetry integration
    c. Integration of security measures and protocols
    d. Advanced analytics and algorithms
    e. Integration to paperless contracts
    f. Integration to people based security
    g. Integration across associated sectors
    h. Developments required for Semantic contracts (including provenance)
    i. Establish and deliver methods to publish outcomes to data.gov
    j. Establish cross sector interoperability requirements
4. Level 3 D (Become a world leader)
    a. Deliver “English” language dictionary and ontology framework and methods
    b. Provide international Internet of Things Standards

"The U.K. government's farsightedness in nurturing BIM advancements has already paid off in improved infrastructure project delivery – which I've had the opportunity to observe firsthand. 'U.K. PLC' has also derived tangible dividends, by virtue of the extended competitive advantage of the British engineering 'supply chain', globally.

The aspirations of Digital Built Britain will next commendably extend the benefits of information mobility from design modeling and construction modeling, through analytical modeling and asset performance modeling – further leveraging projects' Common Data Environments to improve infrastructure owners' operations.

Just as this next level of benefits is acknowledged to require creative adaptations in commercial practice, it will be equally important for continuous innovations to be welcomed from the private sector's technology 'supply chain'. Accordingly, our company and colleagues appreciate our many ongoing opportunities in the U.K. to work in innovative partnerships with enlightened public-works owners to forge and validate world-class 'next practices'.

Moreover, as Britain is increasingly 'digitally built' – to the advantage of all constituents – I foresee that its infrastructure professions will be rewardingly stimulated to contribute towards, and throughout, a more intelligently connected world!"

Greg Bentley - Chief Executive Office, Bentley Systems

d. Cultural

Experience suggests that the transformation of an industry is initiated when new technologies connect with new business models to enable new ways of doing things leading to new and better products and services. If successful, these changes spread across the industry creating new relationships between companies and encouraging new entrants to the industry. This in turn leads to the need for new skills, new jobs, new institutions and a new culture within the industry.

Today the organisation and the culture of the UK construction industry are dominated by the professional services firms that design projects and the general contractors that organise their construction. The engineering and construction work is largely done by the suppliers and sub-contractors that make the components, employ the skilled labour, own the plant and assemble the project on site. The culture of the industry is exemplified by the term "trade contractor" that is widely used to describe suppliers and sub-contractors whether they are SMEs doing bricklaying or multi-national companies providing advanced technologies.

The principal route to a career in the upper echelons of the construction industry is through a university degree in engineering, architecture, quantity surveying or project management leading to a professional qualification awarded by one of the established institutions. People wanting to join the industry's workforce can obtain NVQs in one of the established building trades through an apprenticeship and courses at FE Colleges. Much of the workforce is made up of immigrants who arrive in the UK with skills and qualifications or unskilled people learning on the job.

It is widely recognized within the construction industry that its organisation, its culture and the education and training that supports it are in need of reform. In spite of current concerns about the number of young people entering the industry, we might be training too many people for professional roles and in the traditional building trades and not enough people in the skills that will be needed as the industry embraces the digital economy. As construction transforms itself into a modern digitally enabled industry, it will need fewer quantity surveyors and bricklayers and more people with qualifications in production management, logistics, supply chain management, collaborative systems and data analysis.

The Universities, FE Colleges and professional bodies that deliver much of the construction industry's training today are becoming aware of the changes that are taking place and of the need for new ways of providing people with the skills they will need to find fulfilling careers in Digital Built Britain. This awareness needs to be developed into a debate about the industry's future needs for skills and training and the best way of providing it whether through changes to existing courses or the introduction of new forms of online training supported by CPD.

The transition to DBB will challenge the hierarchical structures and directive style associated with traditional project management. DBB will bring about a paradigm shift in the interactions between people, technology and the environments they work in. They will enable collaborative working in virtual, mobile workplaces and combine a high degree of self-regulated autonomy with decentralized leadership and an enabling rather than directive management style. Fortunately most of the young people who will be entering the industry over the next decade have grown up with social media and have already acquired many of the skills needed to work in this environment.

"..Today most of the world's really smart people aren't members of any single team but are distributed all over the place in multiple institutions."

"Any new model of innovation must find ways to leverage the disparate knowledge assets of people who see the world quite differently and who use tools and methods foreign to those we're familiar with."

John Seely Brown – Xerox Palo Alto Research Centre

Actions – Cultural

1. Level 3 A (Enabling Improvements in the Level 2 Model)
    a. Delivery of accredited learning material through a MOOC framework and effectiveness measurement strategy
    b. Create a client's guidance and awareness of psychological issues, especially in the selection and optimisation of supply chain processes and promote the awareness of personnel security measures
    c. Interface with Construction – 2025, in key areas of making the industry more attractive to new entrants
    d. Stakeholder engagement to increase innovation e.g through world cafe and open space methods
    e. Work with IUK Client Group to encourage good and consistent client behaviours
2. Level 3 B (Enable new technologies and systems)
    a. Delivery of accredited "Learning Outcomes Framework" specifying knowledge, skills and behaviours required at Level 3
    b. Identification of transparency opportunities to support collaborative behaviours
    c. Develop methods for developing leadership capabilities within industry using "Learning Outcomes Framework" for existing and new industry entrant
    d. Identify transparent opportunities to recognise and promote collaborative behaviours through Incentivisation and awards programmes
    e. Provide support to educate and guide government clients in order to become an "intelligent client" to improve selection and optimisation of supply chain processes
    f. Review Incentivisation and link clearly to performance insights with project and relationship outcomes (within this or commercial outcomes)
    g. Deliver research programme into Level 4 – Social Outcomes
    h. Improve corporate communications to enhance protective security
    i. Accreditation framework to ensure consistency of service
3. Level 3 C (Enable the development of new business models)
    a. Support of diversity and equality through the use of technology and open access
    b. Support entrance to industry from underrepresented groups to aid innovation and collaboration
    c. Integrate Learning outcomes with industry and cross industry apprenticeship and training programmes
    d. Encourage new management approaches that focus on outcomes rather than standard procedural project management techniques
4. Level 3 D (Become a world leader)
    a. Review and share successful examples of "Collaborative models of working" celebrating socio and technical elements
    b. Devise feedback mechanisms industry wide which enable double loop learning and integrate within BIM implementation plan and soft landings process
    c. Understand through research the impact of globalisation on the DBB programme and how diversity and inclusion can accelerate uptake and growth

e. Research Requirements

The production of this Level 3 – DBB strategy has been jointly led by BIS, BIM Task Group and UCL. This has presented the rare opportunity to bring together the best of industry, policy and academia. With such a fast moving market it is important to facilitate research which is relevant to maintaining our market position. To this end the academic team led by Professors Broyd, Marmot and Watson have worked to identify research challenges, not the least of these is the way that a number of seemingly disparate 'topics' have emerged piecemeal from different research disciplines in recent years. Whilst good in themselves, there has been little regard to the systems nature of either the topics or the built environment facilities that they serve, with the result that many are currently islands of excellence that are technologically remote from each other. To address this the areas of research identified will include:

- Rapid capturing of accurate, as-built models of built environment facilities
- Linking and calibrating briefed, designed, delivered and operated models
- Using such models to improve whole life performance of buildings and infrastructure networks and systems, including
    - Definition of whole life performance
    - Identification of measurement metrics required
    - Development of methodologies to gather required data
    - Methodologies to deliver useful, timely feedback to improve the performance of both existing and new facilities
- Development of outputs and presentation techniques
- Definition of whole-systems 'performance' for different types of built facility, eg hospital, railway station, school from both the bottom up BIM view and top down Smart City views
- Based on previous experience, current capabilities and anticipated trends, development of a suite of integrated measurement, telemetry, analytic and feedback techniques to allow the performance of the candidate facility types to be understood and improved
- Use of these suites of techniques to be exemplified and verified as working prototypes under live conditions at examples of each type of candidate facility
- Social and socio-technical techniques which can be applied to real life challenges
- Socio-technical behavioral change techniques that can be included in existing education processes
- Understanding of socio-political implications of a smart environment
- Information architecture
- Provenance, traceability and auditability
- Security
- Advanced data sensing and collection
- Anonimisation of statistically important but secure data

To achieve diversity and capacity challenges a number of potential academic partners have been approached to assist in this work.

United Kingdom	UCL – The Bartlett and Engineering Faculties
	Reading – Design Innovation Research Centre
	Cambridge – Centre for Smart Infrastructure and Construction

	Kings College London – Centre of Construction Law
	Cranfield University
	Salford University
	University of Northumbria
International	USA – Stanford – Center for Integrated Facility Engineering
	Penn State University – School of Architectural Technology
	Australia – Queensland University of Technology
	Singapore – Nanyang Technological University
	National University of Singapore

The research activities will be coordinated through the new "DBB-Research" organisation, which will co-ordinate and create a bridgehead between the DBB project, industry and academia. This bridgehead function will include multi-level dissemination and communication between all parties.

Actions - Research

1. Launch "DBB-Research"
2. Create an international sharing forum for research output, ensuring relevance to innovators especially SME's
3. Identify related industries for collaborative working and funding opportunities
4. Ensure all technical research has a commercial and socio-technical consideration

"BIM will be the future IT solution in China; the Chinese Government is strongly supporting BIM"

Tsinghua University, Beijing

f. Domestic & International Growth

The BIM Task Group has been working with EU and International colleagues to understand how the UK can enable a collaborative approach to the production and use of BIM and Big Data in the sector across the international and EU as a whole. This is both to encourage wider acess to the EU market opportunities for UK business but more importantly to help create a world market through our EU partners in the use of consistent BIM and data standards.

We have held a number of workshops to establish an outline plan to be presented to the EU in the summer of 2014, key progress includes:

- EU Procurement Directive which requires consideration to include BIM in EU public works by mid-2016
- Formally creating a group of European central procurers of public works, owners of public estate to coordinate and share best practice
- Set common goals to include:
  - Rollout Level 2 as a standard in EU public works - have specified in public works contracts (over EU thresholds) by 2017
  - By 2018 have 30% of contracts over EU thresholds require use of Level 2 BIM
  - 2025 common Level 3 vision

This EU work is being developed in conjunction with the FCO and UKTI to ensure we maximise our exposure through using existing channels and has served well in achieving the EU formal approvals discussed above and the direct support of both the French and German Governments, both of whom have recently approved their own BIM programmes.

We have also defined a plan to directly influence and support Far East and Australasian nations and will be undertaking a number of invited opportunities both in the public and private sector in 2014 to identify support for both the Level 2 & 3 programmes, including financial.

However the domestic market remains our key focus and we intend to continue our "push – pull" approach, with significant additional support to Government departments in the development of good "clienting" performance and a greater emphasis on the private sector BIM4 communities of which there are currently thirty three. To assist with the emerging software market we intend to extend the existing "Google" and ODI[30] small business incubation principles with a "DBB-Incubate" business that will in collaboration with other private sector providers, including the Daresbury High Performance Computing capability[31], provide support and exploitation "know-how" in a supported environment.

Actions - Growth

1. Using EU resources to ensure a suitable and funded EU strategy is in place to encourage consistent adoption of Level 2 – 3 capabilities across the EU
2. Ensure the 2014 Far East and Australasia commitments are delivered and in collaboration with UKTI & FCO develop the International Outreach programme
3. Launch DBB-Incubate

g. Sustaining the UK leadership position

We recognise that the leading edge of the industry is pushing the frontiers of BIM and data exploitation whereas the majority of businesses are still developing capability in this area and are focused on Level 2 BIM. The current BIM strategy is aimed at bringing Government Departments and the sector up to a common minimum level and the focus on achieving Level 2 BIM compliance by 2016 will remain the focus through and beyond the threshold date. This will continue to deliver Capex savings and most importantly provide a pool of capable and productive digital construction professionals. This community will demand new capabilities and technologies to push their competitiveness forward and we need to commence the Digital Built Britain – Level 3 programme as soon as possible to ensure we stay in front of the game to enable a series of early adopter projects to be operated at Level 3 by 2017.

The leadership shown by the UK Government in the area of digital construction is the envy of the world; our approach and deliverables have been copied and adopted across the EU and far wider. With continued leadership and the delivery of the actions described in this strategy and the creating of the research and incubator organisations, the UK will be well placed to collaborate with all communities to maintain our world leadership position.

Actions – Leadership

1. HM Government to continue to commit to world leadership position
2. Develop relationships with global partners to assist with the localisation of standards and methods as well as developing new standards
3. Continue to communicate direction, progress and lessons learnt

7. Convergence of the Industrial Strategy – Construction 2025, Information Economy and Smart Cities

The single transformational effect of a digital economy is the manner by which data and information flow actively disregard the artificial structures and boundaries humans place around organisations and groups. This can have a disruptive effect (and has given name to the "disruptive technology" phenomenon), but it also presents many opportunities for sharing and communicating with people and organisations that were never thought possible. This is evidenced through systems such as LinkedIn and Facebook and even to some extent e-mail. To create a Digital Built Britain strategy without both acknowledging and capitalising on this opportunity would be to neglect these opportunities. The construction, operations, smart city and digital economy communities are vast, but the data we manage on a day to day basis isn't only shared with these three sectors. We provide services to all sectors…health, education, social, education and transportation and through these transactions we provide vital data for other sectors such as finance and insurance.

Early investigative work with the Financial Services sector has already identified several areas of potential high value collaboration, including the assessment of insurance risk.

The model in figure 6 has been developed to show how this interdependence of services and sector functions could operate, with the focus of providing better services to customers and citizens.

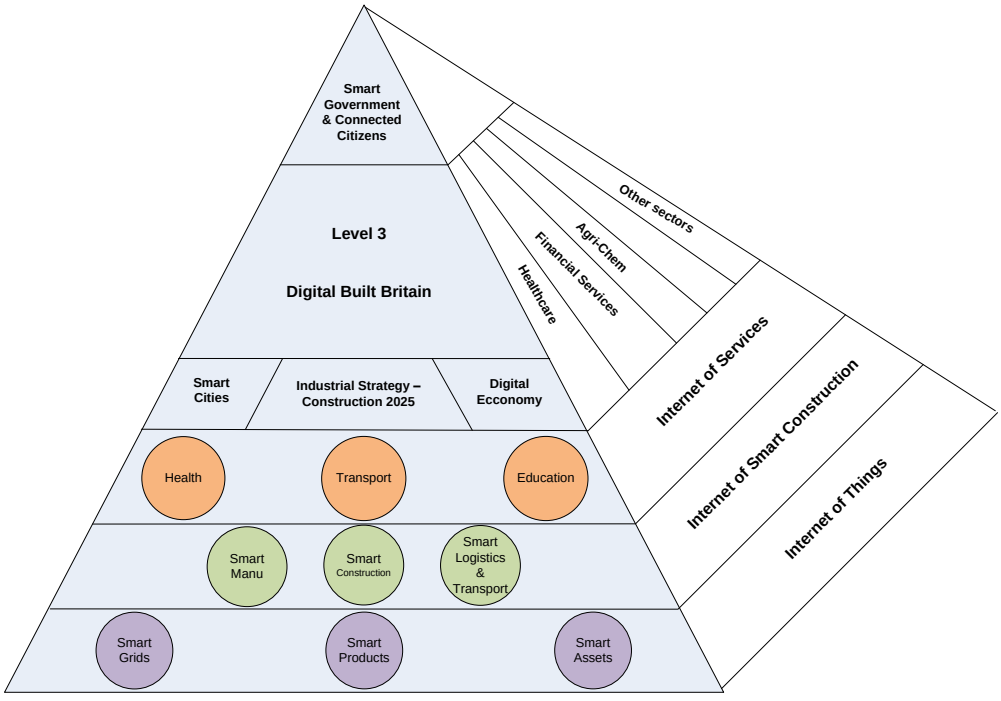

Figure 6 – Cross Sector Collaboration Model

This approach allows for sector integration and cross sector collaboration to manifest, maximising value and opportunity.

Table 1 indicates the key areas where the Digital Built Britain strategy aligns with the Construction 2025, Smart City and Digital Economy delivery plans.

Table 1

#	Construction 2025	DBB – Level 3	Smart Cities	Digital Economy
1	Build the UK's competitive advantage in smart construction and digital design through the Digital Built Britain agenda.	This document describes this Construction 2025 commitment and how it provides convergence between other sectors and strategies, especially the Smart Future Cities and Digital Economy	The ability for the smart city services to be built upon high quality base data which is required for the construction sector to build and maintain assets will enable many future high value service to be developed to enable Smart Cities	The Digital Economy sets to place the UK at the forefront in the use of High Performance Computing, Security and Algorithms. The complex world of the Built Environment is well suited development using these techniques
2	Develop market and technology based plans to secure the jobs and growth opportunities from driving carbon out of the built environment, led by the Green Construction Board.	This strategy places Totex and TotCarbon at the heart of its rationale. The widespread availability of in service data collection and electronic briefing will offer many new opportunities to fully understand why assets perform as they do on a mass scale never yet been possible	Smart City aspirations regarding the use of data to optimise transport options, manage domestic and business carbon usage will dramatically change the way we behave	Provide training and education to underpin the information economy in the UK Accelerate the use of apprentice schemes Provide superfast broadband to enterprise zones and hard to reach areas
3	Identify global trade opportunities for UK professional services, contracting and product manufacturing, develop partnerships and promote UK construction through the great brand.	This strategy describes the current developments in the EU and our future international aspirations, in conjunction with support from UKTI	UKTI have published a "Smart Cities of the Future in Asia"[32] report in Fb 2013 which identified over 100 opportunities for UK business in Asia alone, they further identify the Taiwanese market to be worth £2Bn	Chapter 3 Actions include, A strong, innovative information economy sector, exporting UK excellence to the world
4	Improve the image of the industry by inspiring young people and through a co-	The use of digital briefing and electronic method	The use of modular systems and on line	Construction seeks to attract the best from a

	ordinated approach to health and safety and improving performance in the domestic repair and maintenance market	statements is starting to indicate an opportunity for real improvement in the next generation of industrial and occupational health and safety	analytics will improve the performance of systems and enable productivity improvements in the domestic sector	cross sector resources pool in the technology market. If we are to succeed we need to look to other markets both to learn and collaborate
5	Engage with bodies across the industry to ensure that capability and capacity issues in construction are addressed in a strategic manner	This document describes the technical and commercial interventions we have identified as being required. As with Level 2 these will be documented as contracts or standards and placed within an accreditation wrapper. DBB will continue to be an Industry Lead in Collaboration with Government programme	Smart Cities are engaged with industry bodies for the production of industry guidance and standards through BSI	Information Economy Council will work with the IPO and UK tech clusters to promote opportunity. HMG will work with BSI and ETSI to ensure stakeholders align programmes
6	Develop and refine the pipeline of future work opportunities and make it more useable for all construction businesses.	This document outlines the DBB opportunity that can be applied to this to realise significant benefit and transparency to enable the supply base to respond	N-A	N-A
7	Drive procurement efficiency and explore options for further efficiency gains in the procurement process, led by the Government Construction Board and the IUK Client Group	DBB describes an extensive re-appraisal of the whole contracting model and offers a scoped journey from traditional contracting, through to integrated performance contracts and semantic trading	Smart Cities have a significant interest in the reuse construction industry data. The development of semantic transaction contracts and transparent provenance of data will enable many	The development of semantic transactions will have many cross sector opportunities

			opportunities	
8	Create conditions for construction supply chains to thrive by addressing access to finance and payment practices.	There are cross sector opportunities for greater transparency of payments with a digital economy	N-A	N-A
9	Work with academic and research communities to bring forward more research, development and demonstration to the wider industry and work to remove barriers to innovation	This strategy describes the creation of a "DBB-Research" organisation to focus research across the university sector	Strengthen the UK R&D knowledge base in the areas of Smart and Future Cities, encourage innovation and improve dissemination of information of the cost and benefits of adopting new approaches	Universities UK HMG and ODI will explore the skills shortages in data analytics and set out clear areas for Government and industry collaboration
10	Lead the transformation of the industry through the new Construction Leadership Council, with actions owned and delivered by industry bodies	This DBB strategy has been developed in conjunction with the CLC and other industry bodies, it will continue to collaborate in this work	The Smart Cities Forum and DBB should collaborate to deliver the common vision	N-A

9. Acknowledgements

A vast number of individuals and organisations have been involved in the process of developing this strategy, many have been involved it the working groups. We would like to thank everyone for giving up their time and talent to this project. The project has been chaired by Mark Bew MBE, Hosted by University College London, Project delivered by Tim Broyd, Homeira Shayesteh and Kinda Al-Sayed, directed by the leadership team consisting of

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- Alexi Marmot UCL
- Simon Murray S A Murray Ltd
- Jeremy Watson UCL/Willis
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The following table summarises many individuals who input into work streams, review groups and those who have been consulted, during the course of developing this strategy.

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Alan Penn	UCL		☒		
Alexi Marmot	UCL	☒			
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Anna Fialko	BIS				☒
Anne Kemp	Atkins Global		☒		
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Bill Healy	CIRIA/BIM TA				☒
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Name	Organisation	Work Stream Leader	Work Stream Group	Review Group	Consultation Group
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Kinda Al-Sayed	UCL		☒		
Linda Chandler	Microsoft				☒
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Mark Bew	BIS/CO/BTG (Chair)	☒			
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Mervyn Richards	MR1				☒
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Simon Rawlinson	EC Harris	☒			
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Gary McDonald	Ordnance Survey				☒
Paul Cruddace	Ordnance Survey				☒
Ashley Pocock	SH&BA				☒
Stephen Pattenden	SH&BA				☒

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11. Glossary

Asset information model (AIM)

Maintained information model used to manage, maintain and operate the asset

Building information modelling (BIM)

The process of designing constructing or operating a building or infrastructure asset using electronic object-oriented information

BIM execution plan (BEP)

Plan prepared by the suppliers to explain how the information modelling aspects of a project will be carried out

Capital Expenditure (CAPEX)

Investment focused on the delivery of new assets

Classification

Systematic arrangement of headings and sub-headings for aspects of construction work including the nature of assets, construction elements, systems and products

COBie (Construction Operation Building information exchange)

Structured facility information for the commissioning, operation and maintenance of a project often in a neutral spreadsheet format that will be used to supply data to the employer or operator to populate decision-making tools, facilities management and asset management systems

Common data environment (CDE)

A method to ensure a single source of information for any given project, used to collect, manage and disseminate all relevant approved project documents for multi-disciplinary teams

Data

Values of qualitative and quantitative variables

Digital Plan of Work (dPoW)

Interim MVD designed to work with Level 2 and provide a learning platform for the delivery of production MVD tools

Drawing

Static, printed, graphical representation of part or all of a project or asset

Electronic document management system (EDMS)

System for storing, retrieving, sharing and otherwise managing electronic data

Employer's information requirements (EIR)

Document setting out the information to be delivered by the supplier as part of the project delivery process to the employer

Employer

Individual or organization named in an appointment or building contract as the employer

Graphical data

Data conveyed using shape and arrangement in space

Information exchange

Structured collection of information at one of a number of pre-defined stages of a project with defined format and fidelity

Industry Foundation Class (IFC)

Data definition for interoperable data to enable transparent data interoperability

Information management

Tasks and procedures applied to inputting, processing and generation activities to ensure accuracy and integrity of information

Information model

Information model comprising: documentation, non-graphical information and graphical information

Information modelling

Use of data to provide information through better understanding, by applying logic or mathematical functions to derive new data

Knowledge

Information put into productive use, made actionable, given meaning

Lean

Production focused on delivering value for the employer or client and eliminating all non-value-adding activities using an efficient workflow

Levels of model detail

Description of graphical content of models at each of the stages defined

Levels of model information

Description of non-graphical content of models at each of the stages defined

Master information delivery plan (MIDP)

Primary plan for when project information is to be prepared, by whom and using what protocols and procedures, incorporating all relevant task information delivery plans

Model View Definition (MVD)

Specifically defined data maturity definitions to enable identified transactions to take place (See dPoW)

Massive Open Online Classes (MOOC)

A service that provides online courses with unlimited participation and open access via the internet

Non-graphical data

data conveyed using alphanumeric characters

Operational Expenditure (OPEX)

Costs focused on the operational and maintaining aspects of an asset

Project information model (PIM)

Information model developed during the design and construction phase of a project

Project implementation plan (PIP)

Statement relating to the suppliers' IT and human resources capability to deliver the EIR

(Government) *S*oft landings (G)SL

Systematic inclusion and handover of a built asset from the design and construction team to the operation and maintenance team to allow structured familiarization of systems and components and fine tuning of controls and other building management systems

Standard method and procedure (SMP)

Set of standard methods and procedures covering the way information is named, expressed and referenced

Supplier

Provider of services or goods either directly to the employer or to another supplier in a supply chain

Task information delivery plan (TIDP)

Consolidated lists of information deliverables by each task, including format, date and responsibilities

Total Expenditure (Totex)

The total cost of delivering and maintaining an asset over its lifecycle

User

Individual or organisation occupying or using a built asset for its designed purpose

Virtual construction model

Subsequent version of the project information model developed from the design intent model by the construction supplier and their supply chain

The Government recognises the considerable voluntary contribution made by individuals, construction trade and professional bodies, the construction supply chain, public and private sector clients, academia and numerous industry groupings to our BIM programme and who have all made it the success it is. Government would like to acknowledge and to offer it's thanks to the many UK and international contributors to this document.

HM Government thanks all the contributors to this document. The views expressed by others in this document do not necessarily reflect those of HM Government. The inclusion of such views in this document is not an endorsement of the organisation or individual concerned.

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URN BIS/15/155