In March 2011, the UK Government mandated a 20 percent saving each year on publicly funded construction projects. That equates to £18 billion a year at total UK spend levels. So how can construction get smart and rise to the challenge?

Part of a series of papers on IBM Smarter Buildings
The BIM Revolution

History shows that new information delivers new levels of optimisation. By providing this new information, BIM is revolutionising the construction industry. It’s helping to bring better insight and understanding, reducing construction cost and reducing the cost of occupation by lowering maintenance and energy costs. BIM is also helping to ensure safety in both construction and operation, while providing the visibility to optimise the availability and utilisation of buildings and assets.

Additionally, there’s a worldwide demand to reduce the carbon footprint of infrastructure and better utilise raw materials. Governments and private sector clients are demanding much more for their money and competition is squeezing margins. During the current parliament sitting in the UK, the Government mandated a 20 percent reduction in public sector construction costs. Fortunately BIM has the capability to address these challenges.

The opportunity to cut over £18 billion from UK asset lifecycle costs

In March 2011 the UK Government challenged the construction industry to start using ‘collaborative’ BIM on all public construction projects by 2016. The construction sector contributes £90 billion to the UK economy and this equates to a saving of £18 billion per annum when applied across the whole industry, even more if whole lifecycle costs are considered.

However, those that see BIM as nothing more than a compliance requirement are unlikely to realise the gains that have benefitted related industries such as aerospace and automotive for over a decade. These gains include faster time to market, improved quality, strategic use of product lifecycle management (PLM) data analytics and tighter alignment with corporate strategy. For BIM to deliver these benefits it must first solve a number of major challenges.

Current construction industry challenges

Construction clients are continually looking to increase value, lower risk and be agile enough to meet new opportunities and challenges. This not only manifests in lower cost but also in design innovation, quality of construction and the accuracy and efficacy of construction schedules. Much of the waste in construction is due to localised planning and the inability to achieve an optimised sequence across multiple contractors. The knock on effect is increased build time and higher overall development costs. As construction clients have sought to overcome these issues they have tended to focus on specific steps, whereas the opportunities in BIM are now at a system or multiple step level.

The cost of operation, including facilities management over the life of the infrastructure, can dwarf construction costs. Unfortunately, value engineering activities frequently take cost out of the construction phase but vastly increase the whole life costs. Such ‘asymmetric’ cost pressures often arise from ineffective commercial relationships across the supply chain.

Many buildings such as nuclear facilities and infrastructure projects are enormously complex, and this complexity impacts in various ways. Firstly it drives the overall cost, secondly it increases the risk that certain events will cause upward pressure on cost and finally it creates a multiplier effect on the impact of these events, further raising cost. Consequently the industry needs a way to deal with this complexity.

We also need to be smarter in the way that we exploit complexity by capturing intelligence from numerous interconnected systems. For example, the ability to run analyses prior to build can ensure that these facilities perform to expectation. The same is true of buildings’ environmental credentials. Heating, ventilation and air-conditioning systems contribute to making buildings a significant carbon dioxide contributor. However, subtle design and specification changes can make substantial improvement...
Adopting a new philosophy in managing the asset lifecycle

BIM is a process that uses a digital representation of a facility to integrate activities across the entire lifecycle of the asset. This adds value throughout the Feasibility, Design, Construction, Commissioning, Operation and Maintain, Adaption and Decommissioning phases of its life. Although it utilises various technology platforms, BIM is as much about developing new and more efficient ways of working at a human level as it is about the technology.

Consequently, realising benefit from using BIM requires more than just buying a leading edge tool set. A number of core principles should be applied throughout the asset lifecycle, which means changes to management procedures, business processes, organisational structures and training, along with technology investment.

Given that most built facilities last for many years, if significant improvements and cost savings are to be made, the construction industry should be looking for better ways to run these existing assets more efficiently. Emerging IT solutions that apply analytics to both the BIM and the building data are available to drive down energy costs, improve building utilisation, optimise property portfolio management and maintenance, and reduce environmental impact. Additionally, risk can be better managed to reduce the likelihood of disruptions to business operations, improve safety and where strategic infrastructure is concerned, reduce national security issues.

Collaboration continues to be a challenge for the construction industry. The supply chain consists of multiple organisations in different locations using different systems, resulting in design errors and bureaucracy. An accurate and version-controlled, ‘single truth’ of design, construction and specification data must be made available across the entire supply chain. With more importance being placed on electronic data, issues of intellectual property rights and data security must also be resolved.

to energy performance but the effects of such changes must be modelled before construction commences.

Managing the asset lifecycle

Build the Asset

Manage the Asset
Improved collaboration will deliver a more effective supply chain

Supply chain collaboration with BIM

BIM can optimise collaboration across the entire supply chain. Moves from single-team to global cross-supply chain collaboration require integration from the earliest feasibility stages and complexity is reduced by the use of a single data model, augmented throughout the lifecycle of the facility.

Revision cycles in infrastructure design are accelerating rapidly, taking advantage of collaboration technologies to decrease the breakdown of communication between parties. These process changes, from more traditionally sequenced information development, parallel other industries such as consumer electronics and software development – where global collaboration has led to optimised cost and quality. As the cycle of design and engineering iterations speeds up, enhanced capabilities for revision tracking and traceability are required to manage more free flowing processes of information exchange, while still maintaining oversight and management.

Better processes will enable BIM to deliver value

The process of realising infrastructure involves multiple stakeholders with different information production and consumption needs. Traditional organisational structures have developed to compartmentalise tasks, with distinct lines of control and liability between parties arising via the management of paper documents. Such demarcation introduces systemic risk in complex multi-system assets which BIM can help manage. Doing so demands new, more integrated delivery processes that allow high grade information to flow amongst parties.

When 3D computer-aided design (CAD) was introduced into the manufacturing industry, designers were up in arms, claiming that it introduced complexity and added cost, while others further along the supply chain reaped the downstream benefits. This was in part due to the fact that the underlying processes had not fundamentally changed. They were modelling in 3D and then creating a 2D drawing which was considered to be the master. Now the 3D model itself is considered the master document, so less time is wasted producing fully-dimensioned drawings. Similarly, success in the BIM arena will require the implementation of seamless processes that provide timely access to strictly version-controlled master data.

The real value of BIM lies in the data it manages

To ignore the data stewardship required by BIM is to sacrifice much of the value that it offers. Research in the United States has indicated that lack of interoperability of data among collaborating firms costs the U.S. construction industry some $15.8 billion per year³. For example, the value of as-built drawings reduces over time as configuration changes made during operation are frequently poorly recorded, or not at all. A re-survey can cost considerable sums of money but these costs could be dramatically reduced by BIM-based systems.

IBM believes that data should be secure, accessible and revision-controlled. Moreover it should create value in its own right and be analysed to identify trends that may not be immediately obvious. Additionally, as BIM is used over the entire asset life, the data will also need to remain accessible and up-to-date for that entire period, which for some infrastructure projects could be 100 years or more.

It is also important that the traceability of requirements and contract fulfilment is maintained throughout the whole asset life. This is particularly true of safety-critical facilities such as bridges, railways, oil rigs and nuclear power stations or places where harsh penalties are attached to contractor default. The ability to easily go back to project inception, locate documentation and trace its impact on the design is essential. Furthermore, ‘crowd sourcing’ and consumer analytics can be used to better shape the initial requirements of the asset. This is of great value when it comes to public infrastructure such as roads, railways and stadia, where insight needs to be drawn from many points of view.

Data loss through the lifecycle

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Run simulations to optimise the facility before it is built

For many years, benefits have been gained in the manufacturing industry from the ‘digitisation’ of the real world. CAD models have been used in the automotive industry to run acoustic, stress and crash worthiness analyses long before a prototype is built. The same model can also be used to optimise manufacture and to predict lifecycle costs once the product is in service.

In addition to improved construction sequencing, BIM enables greater use of off-site manufacture, reusable design and mass customisation, leading to lower cost and a better product. Moreover, BIM makes use of advanced analytics to predict and optimise performance before on-site work begins. This can evaluate such areas as energy performance, value engineering scenarios, clash detection, sound attenuation and ‘in service’ usage. The value of energy performance analysis is underlined by the fact that buildings account for approximately 45 percent of CO\textsubscript{2} emissions in the UK.

Integrating systems to deliver smarter assets

BIM can help us to better understand how to extract valuable intelligence from the instrumented, interconnected facility. This may be by smarter simulation and optimisation of the energy performance of the facility before it is built, or by better prediction of how it will be operated. To achieve the maximum potential of BIM we will need to integrate Building Information Management, Asset Management and Process Management toolsets to achieve maximum cost savings over the lifecycle of the facility.

There is no single technology solution for BIM and most BIM adopters use a varied toolset from a variety of technology providers. For example, the majority of facilities will require a ‘federated’ model structure with 3D models drawn from more than one design package, raising the issue of interoperability and standards. Whilst there are already protocols such as Construction Operations Building Information Exchange (COBie) and the Industry Foundation Classes (IFC), they do not provide a perfect interchange. Hence, BIM users need to determine the toolsets and interchange formats to suit their particular applications and continually scan the horizon for new technology innovations.

Maximising value of existing facilities

Older assets that have frequently been subject to undocumented or poorly recorded updates and revisions will diverge significantly from the original design. There is a great deal of discussion around how BIM can be applied to such facilities, with the outcome that there would only be a business case for remodelling assets in certain cases. However, it is possible to scan the existing asset enabling visualisation, measurement and planning.

For example, the UK Government is currently undertaking a series of BIM pilot projects within the Ministry of Justice’s capital programme. This programme includes the refurbishment of a number of wings at Her Majesty’s Prison (HMP) Chelmsford where the design team led by Aedas is employing laser scanning technology to capture the existing buildings. These techniques offer a number of benefits, including minimal disruption to the establishment’s operation and increased richness of data collected. The cloud data is used to construct a BIM model of the existing building, which forms the basis of the design development and subsequent construction processes, bringing all the benefits BIM offers to the existing building scenario.

Furthermore the instrumentation of existing facilities, which is connected to the building management system, can be analysed and stored in the form of structured digital information to provide valuable insight into the facility’s performance. IBM recommends that this information should be stored as part of the BIM model and is equally as valid as the COBie data used to transfer other non-geometric BIM data between systems. Moreover, large or specialist facilities management companies who amass large volumes of data on asset performance should look to monetise this insight by providing controlled industry access to the data.

Andrew Barraclough, Director at HOK, says: “There is huge interest from our clients in the downstream benefits that BIM provides to the efficient operation of their asset. For example, with an existing BIM model we can simulate pedestrian footfall, queue and dwell times for future configurations to test revenue generation, rental values and the return on investment well before any design work is undertaken.”

Buildings account for approximately 45% of CO\textsubscript{2} emissions in the UK.
The constant challenges involved in minimising cost, reducing procurement time, ensuring innovative design and adapting data to business needs are the drivers for BIM adoption.

To make BIM a reality, IBM has developed a six-step roadmap which determines what is required for successful implementation.

1. Understand the value proposition
2. Set requirements
3. Understand the information requirements
4. Choose the technology
5. Implement the change
6. Realise the benefits.

1. Understand the value proposition
The first step in implementing BIM within any organisation is to understand exactly where value can be generated. This may seem obvious, but misunderstanding the value to be delivered is a common error. Also, as adopters innovate and new value propositions emerge, we must be better placed to learn from each other to ensure that the benefits are available across the whole industry.

For designers, this may be through greater productivity and reusability of designs. For construction companies, it may be through better sequencing of construction and off-site manufacture, whilst for facilities management, it may be through the improved ability to contribute to the feasibility and design process, better loading of assets into their facilities management system and subsequent configuration management. There will also be ‘whole system’ benefits across the entire supply chain which may require a new commercial model. IBM knows that it is critical to understand the value proposition because it creates the foundation for BIM within the organisation.

Although most of the industry focus is on design and construction phases, there are many other potential benefits including:
- Faster and reduced cost mobilisation for asset maintainers
- Better staff induction
- Improved building security and evacuation planning
- Reduced energy requirements through occupancy management and zoning.

By understanding the business case, the substantial investment in technology and process changes can be validated. Furthermore, the value proposition will set the business priorities that form the basis of the solution selection, as well as specifying the business measures used to evaluate the improvement.

2. Set requirements
Once the value that can be extracted from BIM is made clearer, the particular business requirements can be mapped. These will relate not only to system functionality, but also to the processes to be employed. Adopting a structured approach to requirements mapping will ensure a smoother implementation process, with no surprises.

During the requirements collection stage, it is important that all stakeholders are consulted. This must not be an exercise that is carried out by the IT department and ‘done to’ the rest of the company. Consultees will include users of the systems at each and every point of the lifecycle and this extends to the whole supply chain, even if they reside outside the organisation.

Finally, requirements should be collected in a structured format to provide a richer view for stakeholders and allow traceability once the final system is delivered. This will ensure that a BIM adopter will continue to receive the same BIM capability that they specified at the beginning of their BIM development process.

3. Understand the information requirements
The value of BIM resides in the data that is produced in the early stages of design and then flows through the construction and facilities management stages. IBM is passionate about data being treated as an asset in its own right because of its ability to deliver value. It should be subject to ‘Master Data Governance’ to ensure that its value is not eroded by uncontrolled changes or by confusion over the latest version. These concepts form part of IBM’s Data Governance Maturity Model – see Figure 1.

With increasing collaboration there is also an increasing danger of fragmented design responsibility and of a defective design being supplied by someone with no contractual liability. To mitigate this risk, data provenance and traceability techniques should be used.
IBM promotes the use of standard data interchange formats such as COBie and IFC. However, users should also be aware of the shortcomings of these standards and consider the proprietary interfaces that are being introduced into the marketplace. Ultimately, users should adopt a BIM data strategy that works for them, one that is as open as possible to ensure maximum inclusivity of the entire supply chain.

Adopters of BIM need to be aware of the vast amount of data that can be built up during the construction lifecycle, and the importance of it being made available across multiple sites, organisations and geographies. This further highlights the significance of developing a data strategy before deciding on the BIM solution.

Finally, any data strategy needs to consider the issue of intellectual property and liability issues. Solutions must be developed in conjunction with the legal agreements drawn up at project inception and be flexible enough to allow for different legal arrangements.

4. Choose the technology
BIM technology is constantly evolving and there will not be one single solution that will satisfy a user’s needs. Solutions will also vary by industry. For example, complex applications such as nuclear power plants will require a toolset that not only enables modelling of detailed geometry, but also provides the ability to carry out sophisticated simulation of construction, process, maintenance and decommissioning operations. Conversely, organisations that are developing less complex assets should consider simpler and less expensive toolsets.

The choice of technology should therefore be selected based on a detailed options appraisal, which uses as its evaluation criteria the requirements developed in stage 2 of this process. These could be, amongst others, cost savings, quality improvement, ease of use or ease of integration.

5. Implement the change
Adopters of BIM need to understand the capability of their staff to embrace BIM concepts and practice. As with any new methodology, new behaviours will need to be embedded and this will involve a wide range of training requirements. Karl Redmond and Tim Platts of the Construction Sector Network BIM Group state that: “If those already engaged in the BIM agenda do not transfer knowledge and support the right training programmes regarding BIM, we will soon discover a skills and understanding shortfall which will ultimately undermine the changes to the ‘core principles’ as highlighted by IBM and others.”

IBM also believes that BIM adopters can learn from IBM’s best practice of implementing large scale product lifecycle management (PLM) and asset lifecycle management solutions in the aerospace, automotive and maritime industry on a global scale. These experiences can shape expectations as to the realistic speed of adoption and productivity targets to be met over both the short and medium term.

6. Realise the benefits
Following the implementation of new systems, the benefits are unlikely to be realised immediately. Therefore, it is crucially important to identify metrics that will provide insight as to whether the value that was predicted in stage 1 has been achieved, and make alterations to the implementation if this value has not been delivered.

By putting the process measures and dashboards in place to track benefits against the value propositions and the requirements, continuous improvement can be used to hone processes and data requirements. This will consolidate the business case for future investment, which will deliver even more benefits as the BIM capability matures.

BIM – further information
In this paper, IBM has set out the challenges and enormous opportunities that BIM presents to the construction industry and highlighted key principles that will help maximise value for adopters of this technology. IBM is committed to supporting its clients and partners, optimising their BIM investments and delivering the goal of smarter buildings and a smarter planet.

To help construction companies to successfully implement and manage BIM, IBM can provide business and technical consultancy, implementation support and tooling. For more information, please contact Jason Allan: jason.allan@uk.ibm.com.
IBM contacts
Steve Hornsby
Partner, Asset Management Solution Area
and Nuclear Industry Leader
IBM Global Business Services
+44 (0)7703 401541
steve.p.hornsby@uk.ibm.com

Jason Allan
Managing Consultant (BIM)
IBM Global Business Services
+44 (0) 7771 694848
jason.allan@uk.ibm.com

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IBM United Kingdom Limited
76 Upper Ground
South Bank
London
SE1 9PZ

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3. The National Institute of Standards and Technology (NIST), Inadequate Interoperability: A Closer Look at the Costs

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