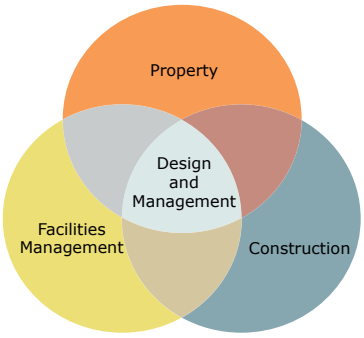
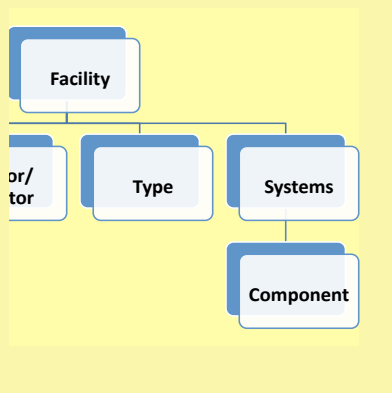
Growth through BIM

Richard G Saxon CBE





Construction Industry Council

'Civilization advances by extending the number of important operations we can perform without thinking about them'

Alfred North Whitehead OM FRS 1861-1947, philosopher and mathematician.

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Growth through BIM

Royal Sussex County Hospital for Laing O'Rourke: Planning application material from the model

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Introduction and summary.

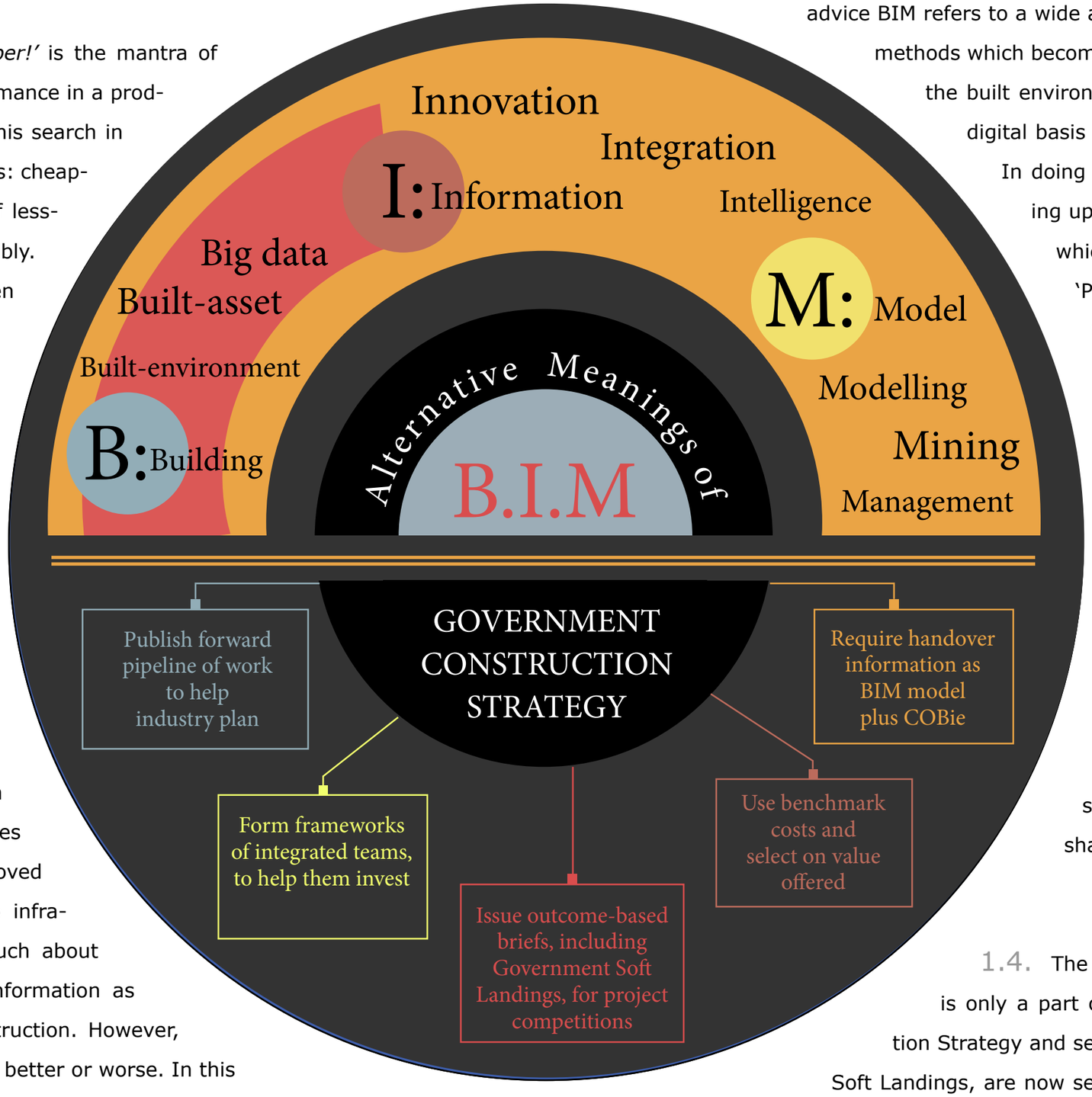
1.1. This advice was commissioned by BIS through the Construction Industry Council on July 1st 2012. Its terms were:

- To report on how best to turn the government strategy for BIM into economic growth in the home and export markets; this task, as 'BIM Ambassador for Growth', required:
- keeping a watching brief on key international developments in BIM.
- helping ensure that the current EU Procurement Directive revision clears the way for UK policy and for the export of its methods within the EU.
- reporting to the CIC and BIM Task Group and Steering Group by the end of March 2013.

This report is based on research done in Q3-4 of 2012. The development of the BIM idea is currently rapid and the subject will continue to evolve during 2013 and beyond. Refinement of the proposals will be possible over time.

1.2. *'Better! Faster! Cheaper!'* is the mantra of all who seek improved performance in a product or service. For decades this search in construction has been fruitless: cheaper or faster usually meant of lesser value; cost rose inexorably. Productivity growth has been flat whilst in other sectors it has risen hugely. Now we have the arrival of a way of working which promises to design and build assets more cheaply and faster but also to make them better performing. No wonder it has been mandated as government policy.

1.3. Building Information Modelling (BIM) as a term dates from around 2003. It has proved inexact as it also applies to infrastructure work and is as much about the management of asset information as its initial modelling for construction. However, the name 'BIM' has stuck, for better or worse. In this advice BIM refers to a wide and widening suite of working methods which become possible or necessary when the built environment industries move onto a digital basis and use artificial intelligence. In doing this the sector is only catching up with most modern industries which have been using parallel 'Product Lifecycle Management' technologies for two decades. As revealed in those other sectors, this is a 'Disruptive Technology'. It causes creative destruction of business models. Whilst 2D CAD allowed traditional practice to become more efficient, BIM suggests new practices altogether. Some will lose from this whilst others gain; the entire sector will be progressively reshaped.



1.4. The UK Government BIM strategy is only a part of the Government Construction Strategy and several of its elements, such as Soft Landings, are now seen as BIM-enabled. They are

included in this report as being in the 'BIM Space'. Since declaring the BIM Policy in May 2011, the Government BIM Task Group has progressed rapidly in developing practice and in implementing the policy. This has, according to outside observers, put the UK in a leadership position amongst national governments and it has been suggested that economic advantage might flow to the UK if this leadership is maintained and exploited. This report puts substance behind that thinking.

1.5. The impact of BIM will be felt not only across the construction sector but throughout the built environment industries: Property, Construction and Facilities Management, together about 15% of UK GDP. It will be a factor for growth by reducing cost and risk, encouraging use of construction, but also by increasing value of many kinds. It will begin the digitisation of the UK asset base, increasing the achievement of desired outcomes and the economy of means. BIM will be part of the conversion to a 'Smart' economy, where data is collected and used to optimise performance and economy.

1.6. The UK construction industry will have fallen from 3% in 2008 to only 2% of the global industry by 2020. All of the growth this decade in world construction will be in the developing world, which will represent the majority of demand by the end of the decade. Most of the developing world needs to import design and some construction services for its major projects and this represents a significant opportunity for growth in UK construction services whilst home demand is subdued. BIM use is normal now for the front-end services on overseas infrastructure and building projects. Its use later in the project cycle and further down the supply chain will advance during the decade. Cloud computing will be the main method of storing and sharing a model and this will facilitate worldwide access to them. The UK has a powerful professional services resource for international work but the USA dominates the global market at present. US firms or shareholders are also progressively acquiring the commanding heights of UK professional services such that we can, with exceptions, really only speak of UK-based professionals, not of UK-owned ones. Export of UK based services will be helped by increasing the acceptability of UK standards. The UK also has an opportunity to lead EU construction policy development, to the benefit of our industry.

1.7. BIM will bring growth to the UK economy where it serves national goals which 'pull' demand through. These pull factors include the desire:

- To reform the construction industry into a customer-focussed one, delivering outcomes not simply outputs and at substantially lower cost;
- To respond to returning demand with less inflationary pressure.
- To achieve sustainability in the built environment; more economical, environmentally sound and socially positive.
- To develop 'Digital Built Britain,' the concept of a data-driven asset base.

1.8. The 'push' factors where BIM will promote growth include:

- reduced cost, risk and time in design, construction and operation of buildings, based on the creation of a 'Single Source of Truth' for all parties;
- potential for higher whole-life value from comparable investment;
- expanded services to clients to raise the quality of their outcomes;
- enhanced international competitiveness, with reduced importing;
- offsite construction for economy, speed and safety reasons;
- emergence of the ICT sector service as part of construction.

Growth will become apparent after a period of investment and learning by teams.

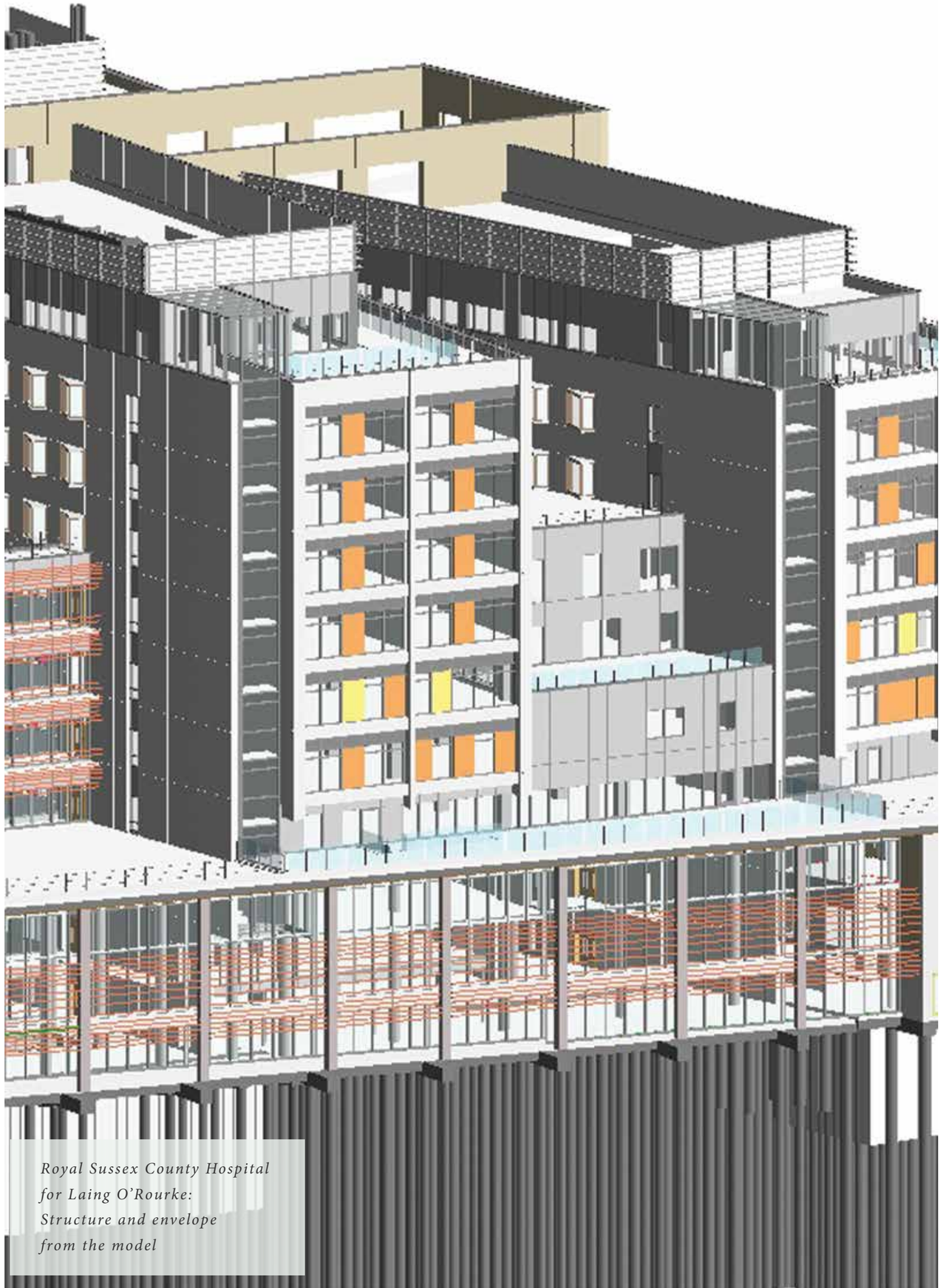
1.9. BIM will develop much further by 2020. The UK concept of BIM Levels: 1, 2, and 3, is proving very useful. Level 2, an intermediate step not requiring changed commercial arrangements, will be established by 2016, with Level 3 still to be defined or given a target date. The UK has vaulted into a world BIM leadership position as a result of its government mandate and the worked-out methodologies now created. How the BIM world moves forward is very much open to the UK to steer, in the EU and globally, to the advantage of our suppliers and our GDP.

1.10. The stakeholders impacted by the arrival and development of BIM spread across the entire built environment sector, its regulators and its clients. A new Digital Workplan has been devised to guide changed practice. Each profession and trade will be substantially affected, even by Level 2, with challenges to established business models as well as opportunities for expansion. There will need to be a major educational effort to facilitate the skilful uptake of BIM and avoid it being discredited by incompetent practice.

1.11. Government can ensure the maximum growth effect from the introduction of BIM by taking or facilitating others to take a number of actions set out in Section 6. These will:

- complete the remaining parts of the regime needed for successful Level 2 working;
- lead the development of the global foundations for Level 3;
- help UK industry to export more successfully through BIM.

There is no doubt that the policy of mandating BIM use for government work will create economic growth. The scale and speed of the effect is not quantifiable as yet but should become so if monitoring is well done.



Royal Sussex County Hospital for Laing O'Rourke: Structure and envelope from the model

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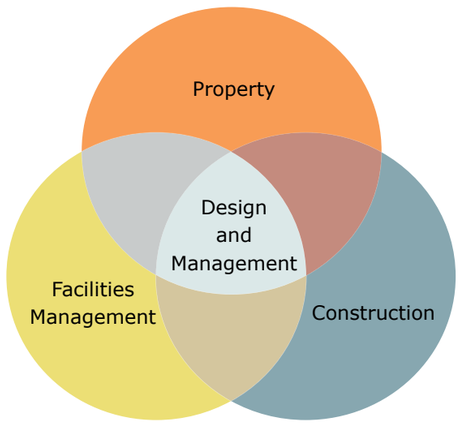
Scale and shape of the market, UK and worldwide:

2.1. BIM economic effects spread over not just the construction industry as defined in ONS statistics but across the Built Environment, defined here as Property, Construction and Facilities Management (ref 1). Construction is defined statistically as that value which passes through the books of contractors, about 6.7% of GDP currently, but much higher in the recent past (ref 2). This capital spend is about half of all UK annual fixed capital formation but because of their long life, built environment assets represent 75% of national fixed assets.

Three sectors form the built environment



2.2. Design and management services to projects represent another 1% of GDP (ref 3) and are classified as Business Services. Half of the annual construction capital spend is also classed as Repair, Maintenance and Improvement, the realms of Asset and Facility Management. Trade in, operation of and management of buildings and property (Real Estate Services) is another huge part of the economy: 7.1%. All these operations will be transformed by BIM-related practices. In total therefore, BIM will impact directly on nearly 15% of GDP.

2.3. Indirectly, BIM will influence performance in the sectors which occupy and use buildings and infrastructure. Built environment is an enabling sector, facilitating the performance of most other sectors. Built environment is also the dominant consumer of utilities, electricity, gas and water, the source of most waste, plus the locus of almost all fixed ICT. BIM will affect performance in these sectors. Infrastructure is a substantial part of the built environment and is mapped on geographic information systems (GIS). GIS and BIM developed separately but are conceptually related and should become seamlessly linked to enable better development and regulatory control. The Internet of Things (IoT, where sensors on objects communicate via the Internet Protocol) is emerging as a further factor. This affects how building elements are tagged, shipped and tracked, but also how they can form a sentient system to support the construction and operation of the building, infrastructure element or district. BIM will link into IoT, providing 'Big Data' and tools to manage the so-called Smart City environment and the Smart Grid for power management.

2.4. The major opportunity for UK-based construction businesses in the current decade is to win work in the expanding markets of the developing world. Currently about £7.6Bn is earned by export, around 1% of contracting work, 4% of consultancy and 10% of materials and products business. Global Construction 2020 (ref 4) in 2011 set out the expectations of a team of economists for the pattern of demand in the current decade. This forecast might now be considered somewhat optimistic about recovery from the recession, but its pattern of relative positions is still relevant. Demand flows from a combination of population growth and its urbanisation rate, economic growth and propensity to invest in construction as a proportion of GDP.

2.5. Global Construction 2020 says that the annual amount of construction to be done globally will rise to $12tn in 2020, up 67% from 2010 and forming 13.2% of world GDP. $97tn will be spent in the decade. The growth will come entirly from the developing world;

Wuxi Shopping Centre, atrium, for Inter Ikea Centre Group

Hongqiao Business District, Shanghai, for Golden Kingdom

North America and Australia will recover well from the present slump but Western Europe will be very slow to rebound. By 2020 the ratio of turnover between the developed and developing world will have shifted from 60:40 in 2010 to 45:55. Developing countries will be spending an average of 16.5% of their GDP on construction, up from 14.7% in 2010.

2.6. 65% of the demand growth will come from China, India, Indonesia and Russia. India will overtake a falling Japan as third largest market but will still only be 1/3 of the size of the giant Chinese market. The USA will be No2, spending $14.5tn by 2020, led by non-residential investment. Turkey will overtake Poland and Brazil will be driven forward by its sports events. The Middle East and North Africa will see $4.5tn spent in the decade, up 80%. Qatar and Saudi will be big spenders but numbers are small compared to East and South Asia. In Africa, Nigeria rises from a low base and South Africa will be active but not surpass its 2010 spending.

Eco Housing , Nanjing, for Landsea

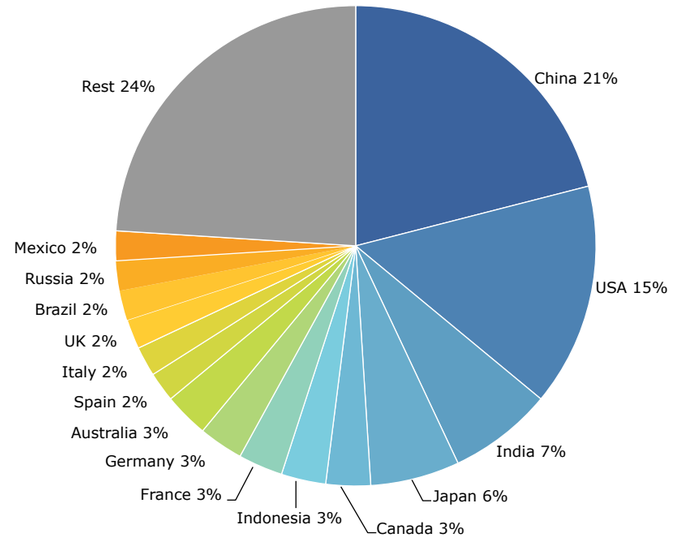
Indian Institute of Technology, Mandi. Masterplan (top image). Lab Section (bottom image)

2.7. In Western Europe best growth hopes are for the UK and Sweden whose populations are rising. Falling populations and/or debt overhang affect most other countries, including Germany. Australia and Canada together outpace Latin America as a whole due to their resource driven economies and demographics.

Bispebjerg Hospital, Denmark, for Bispebjerg and Fredrikberg Hospitals. Aerial view

2.8. The world construction market in 2020 will be made up of 40% residential building, 32% infrastructure and 28% non-residential private and public building. Infrastructure pulls consistently throughout the decade, where the second half is generally slower than the first half. The pie chart of top markets shows:
China on 21%, USA 15%, India 7%, Japan 6%, Canada, Indonesia, France, Germany and Australia on 3%, Spain, Italy, UK, Brazil, Russia and Mexico on 2% and the rest at 24%.

Global Construction Volume in 2020



2.9. The scope for BIM to serve this global market will depend on the uptake of the BIM approach across the world. Full exploitation of BIM on a project requires clients, consultants, constructors, product makers and facility managers to participate digitally. At present most projects designed in the west for the developing world use BIM only for their early stages as host country constructors are not able to work in BIM mode (China is an exception). Pike Research reported in 2012 (ref 5) on the demand for BIM software and services to 2020. BIM S&S markets are well developed only in North America and Western Europe at present, but with Asia Pacific growing fast. Pike does not expect uptake in Latin America, Middle East/North Africa and Africa until late in the decade. They see the major opportunity for BIM in the commercial building sector where its economics prove self reinforcing. World demand for new commercial construction by 2020 will equal current US stock.

2.10. Another factor in the world spread of BIM will be Cloud Computing capacity (ref 6). BIM is suited to Cloud applications, both to provide Software as a Service (SaaS) and to hold sharable models accessible anywhere. Careful planning and management is however needed to use BIM on the Cloud securely, but the approach is very likely to prosper as it will be more economical for users. It also allows building sites to use models on a 4G mobile broadband basis, supported by high definition teleconferencing. This will be very attractive to constructors used to late and poor site landline services.

Software as a Service

Instead of buying software and installing it on each machine, users can subscribe to run the software as an application held in the service-provider's servers. They pay for time used, do not need to make capital payments or update each user machine when updating is required. They can also run less high-end machines as the processing is done at the server. With BIM, the model may also be stored online and shared via other applications.

2.11. Cisco reports (ref 7) that Cloud capacity is growing at a Compound Annual Growth Rate (CAGR) of 31% and will be four times its 2011 capacity by 2016. By then two thirds of all world workloads will be processed in the Cloud at a far greater server utilisation than is achieved in traditional servers. Again, North America and Western Europe lead Cloud deployment and fixed and mobile access to it in 2012. Asia Pacific catches up with more users in total by 2016. Fast growth in Middle East-North Africa, Latin America and Eastern Europe, from a low base, makes them significant users post 2016.

2.12. Price Waterhouse Coopers (ref 4) expects the global construction industry to consolidate to meet demand, to mobilise private investment funds, alter their business models, customer mix and supply chain methods. Local and global working will generally be distinct.

2.13. The UK is second only to the USA in exporting construction services to world markets. Developing countries can rarely meet their own demand for services to support their high investment in construction. They particularly pull in professional services to plan and manage programmes, design infrastructure, masterplans and buildings, and manage construction. The leading UK consultancy firms handle £10bn in fees annually (says ACE) and control the international contract form, FIDIC.

2.14. The arrival of BIM since the early 2000s has been USA-led. The big US consultancies have used their first-mover advantage to penetrate world markets further and to consolidate their ownership of former rivals outside the US. Many formerly UK firms have become part of US majors since 2005 and most of the remaining UK domiciled

firms have shareholder patterns which span the world. ACE, the grouping which lobbies for the major consultancies, estimates that there are 100,000 staff based in the UK which are part of firms with a total employment of 500,000. International working is a field dominated by large firms. This comes from the large investments needed to win work and the operational efficiencies possible such as 24-hour working around global offices, enabled by BIM and the Cloud. Lead firms act as 'mother-ships' to others involved, providing the technology platform and programme management. As risk is progressively being managed down by BIM and programme management methods, so consultants are competing with contractors to play the integrator role. In turn, several international contractors have acquired consultancy arms. The categories have blurred.

2.15. BIM-based working has become essential for international work before doing so within the UK. Almost all pre-construction work is done in BIM, for its speed, quality-control, presentation polish and risk reduction. After that stage the use depends on local contracting and product suppliers and varies widely. The changes caused by BIM-based working are cultural and firms are collaborating through ACE to compete on new terms. Together with the new capabilities in programme management, BIM can help aim for a 'zero-failure' regime for enlightened clients. This involves high investment in preparation before design and build, in commissioning after building and in operational follow-up. Service is based on delivering outcomes and this involves not stinting on the early stages. Payback on the investment still lies ahead for most players.

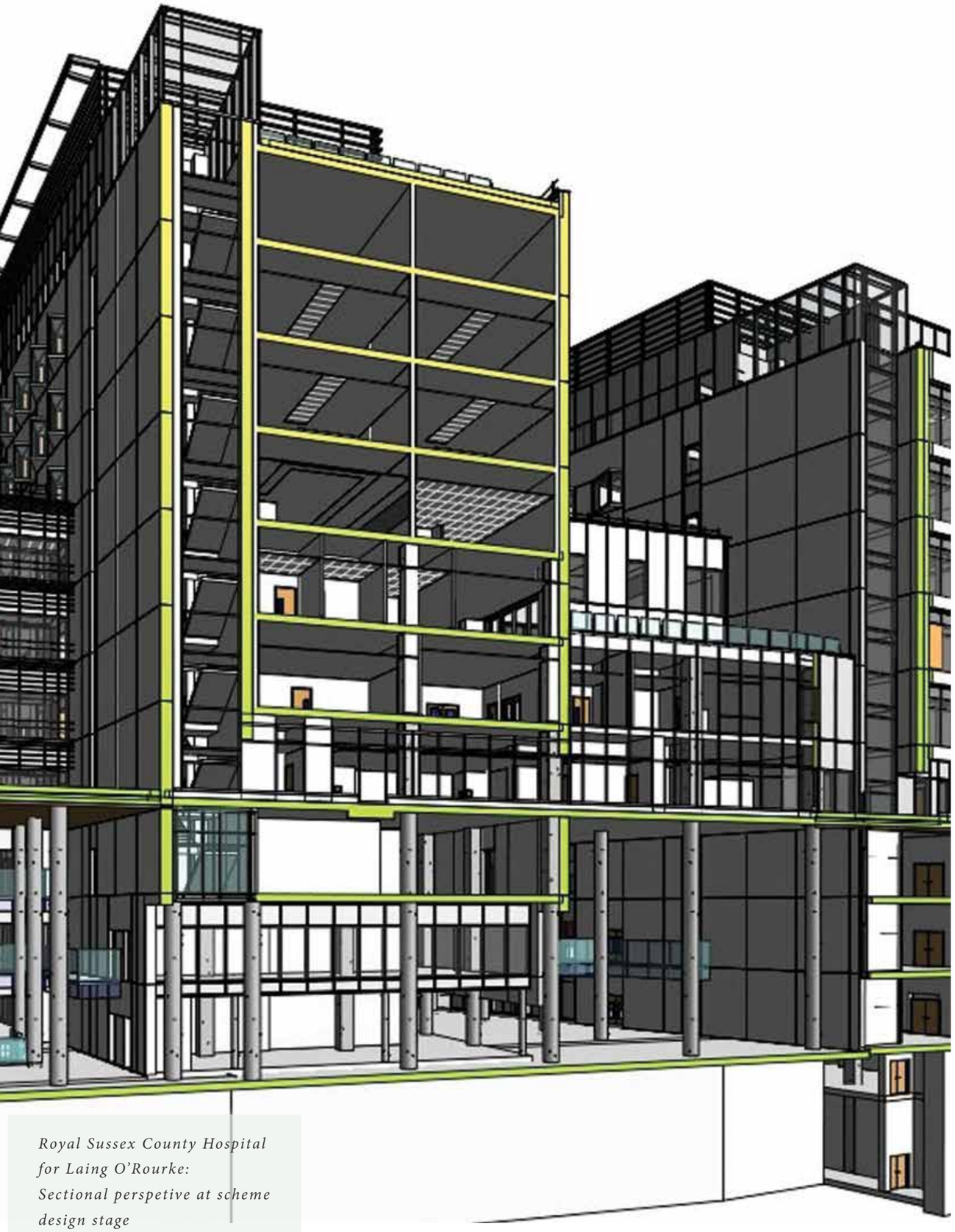
2.16. Figures available for architectural exporting suggest that the same scale effects apply as in engineering and programme management. The top 30 US architects earn £1.3bn fees annually outside the USA (ref 8). Many earn more than half their income there and derive fees from across the building type spectrum, from healthcare to commercial and public building. The Middle East dominates their market, followed by Western Europe, Canada and Mexico, China, India and Latin America. UK architects earn only 10% of their £2bn fees abroad (ref 9) with the largest practices earning 15% on average. One firm however, Foster and Partners, earns 90% of its fees abroad, as much as many of the US giants and twice that of the rest of the UK firms together. Apart from its other advantages, Foster is a major user of BIM.

2.17. Export of UK construction services and products is most practicable into countries which recognise UK classification, standards and contract processes. The old Empire and Commonwealth, plus places once under British mandates, usually retain a standards and code regime close to that in UK. Other countries, and some of the former UK territories, have adopted US, German or EU codes and standards. These have been actively sold by their proponents and it is an effective non-tariff barrier to trade from the UK. One arm of any export drive must be to spread the reach of UK standards. Semantic Web-based methods of converting UK classification standards into others offer another route to working in other nation's conventions (ref 10).

2.18. The European Union represents a special opportunity for the UK. The single market is essentially limited to labour and products so far and political efforts centre on extending this equally to services. Lobbying in regard to the revised Procurement Directive is in progress to see that use of BIM becomes encouraged and even mandated across the EU. The UK is the most advanced large-country user and could take advantage of a more open market for BIM-based services. Our main usual rival, Germany, is hamstrung by its heritage of protected professional services and fees. Whilst government and some clients like Deutsche Bahn are enthused, professionals are reluctant to venture outside their protected zone and are therefore not competing on a BIM basis yet in Europe or beyond. Apart from the Scandinavian countries and Holland, no other EU countries are yet fully alive to the potential. PuREnet, the network for Public Sector Real Estate, brings together EU civil servants on issues of all kinds. BIM experience is being shared there but beyond the countries mentioned above has not reached the ears of politicians. The EU Commission has published a Construction Strategy which it hopes to pass through the Parliament and Council in 2013. BIM is not mentioned in it so far and this represents an opportunity for the UK to lead EU policy development, to advantage.

2.19. The EU Construction Products Directive comes into force in 2013. The Directive calls for consistent and better information to be made available with product offerings. It does not specify that this should be BIM-based but this is the obvious opportunity, both to serve designers and constructors and owners and facility managers. UK product manufacturers can advance internationally by responding to the UK market demand for BIM-based information.

Cultural Centre, Sabah al Ahmed, Kuwait for Public Authority for Housing Welfare. Aerial view (top image). Street view (bottom image)



Royal Sussex County Hospital for Laing O'Rourke: Sectional perspetive at scheme design stage

3

The basis for BIM-driven growth: the Pull and the Push.

3.1. BIM is a supply-side phenomenon, offering changed performance to the market as 'Push'. What will determine how it changes the industry will be the customer 'Pull', the services actually sought by the market. In 2008 the National Platform for Construction Technology, the industry research focus, published a 10-15 year strategy for construction research, based on polling research heads across the industry. It came to a consensus that there was a tripartite goal for the industry:

1. To become fully customer-focussed, knowledge-based and value-driven, basing its approach on what clients, occupiers and society need from the built environment;
2. To become sustainable, economically, environmentally and socially;
3. To use Information and Communications Technology and Automation (ICTA) to help achieve these goals.

These three goals are clearly interdependent.

3.2. The two first goals represent an almost complete reversal of the positions of the industry at the start of the 21st century and are thus colossal undertakings. The industry has historically been seen as deeply unfriendly to its customers, fragmented, unable to learn, self centred, hard to buy from and with relentlessly climbing costs. It was unsustainable in its low productivity and profitability, negative ecological impact and threat to the health and safety of its workers.

National Platform Reports

FULL DETAILS AT:

www.nationalplatform.org/uk/publications.jsp

- Research Priorities for the UK Built Environment, plus three scoping studies:
- Building a Client-oriented, Knowledge-based, Value-driven Industry.
- Reduced resource consumption in the built environment construction industry.
- ICT and Automation scoping study.

3.3. BIM and other ICTA applications allow these goals to be realistically approached. Digital information management enables customers and their desired outcomes to be better understood, based on feedback. Design simulation enables stakeholders to understand what they are offered before it is fixed. Construction simulation removes time and uncertainty from sitework. Waste, pollution and risk to safety are reducible by computer-aided design and offsite construction. Collaboration across the supply chain is supported and rewarded. In spite of still-rising commodity and labour costs, prices can be cut whilst supplier profits increase. Buildings can be more confidently operated to deliver performance expectations and at falling whole-life costs. The current **Government Construction Strategy** effectively adopts the key elements of the 2008 National Platform strategy, pulling development forward. Above all it seeks cost reduction of 15-20% by 2015.

3.4. **Returning demand.** After a conventional recession, returning demand hits capacity constraints as a result of lost capacity in the industry. This creates cost inflation as pricing power returns and capacity is rebuilt. This long recession has destroyed a large part of UK construction capacity. However, BIM raises productivity substantially, substituting for both professional and site labour and cutting material use. It is anti-inflationary. Returning demand will cause clients to pull suppliers to employ BIM as one way to reduce inflationary pressures.

3.5. The national policy to cut carbon dioxide emissions deeply by mid-century is another 'pull' factor for BIM. **Low carbon construction** requires more sophisticated design methods, higher site construction standards and better building operation practice. BIM helps to achieve this by cutting overall costs, thus making higher standards more affordable. It also helps retrieve good carbon data and run good simulation programmes for efficient design, supports offsite construction with its lower waste creation and provides operational support to run buildings well, notably through the Soft Landings initiative. BIM used to measure BREEAM ratings can ensure that the chosen rating is not degraded during value engineering, raising outcomes. Most powerful is the synergy between low cost and low carbon: BIM helps make low carbon affordable.

3.6. The Government also seeks to make the UK into **'Digital Built Britain'.** This concept involves creating a data model of the entire economy and managing it with the help of massive information flows. Major efficiencies are anticipated, together with improved services. For the built environment sector, this involves progressively capturing the public estate digitally. The flow of 'Big Data' from facilities in use will transform public clients' ability to plan future services and projects. The programme therefore calls for future construction and refurbishment to be on a BIM basis.

3.7. The successful suppliers of the next period will be those who discern customer needs clearly and meet them profitably, not those who exploit the information and decision making weakness of clients and fellow suppliers. Those weaknesses are much reduced through BIM use.

3.8. Economic growth will flow from the 'push' of BIM and related innovations in several broad ways:

3.9. BIM use progressively **reduces the cost, time and uncertainty** of design, construction and operation of buildings by making previously laborious and ambiguous processes quicker and more accurate. It provides all involved with a 'Single Source of Truth' with which to collaborate more successfully. Building types are becoming differentiated into a spectrum from 'standard' (eg. parking garages, warehouses) to 'bespoke' (eg. museums, refurbishments), with those between the extremes using standard elements to a greater or lesser degree. BIM facilitates both the retrieval and re-use of standard elements and the creation of complex bespoke elements. This all breaks the multi-decade cycle of low or no productivity increase in construction, beginning a cycle of rising productivity. Professionals and contractors will take up BIM to help them rebuild margins in a very low-cost market. Demand for building which is currently depressed by its slowness, high cost and risk, should rebound. For example, institutional funds might be available to develop infrastructure and housing to rent, given a much lower risk of cost overrun.

3.10. BIM creates the potential for **higher whole-life value** in the built environment. The lowered cost of building will enable higher specification to be more affordable. This may take the form of higher energy efficiency and lower life-cycle costs. It may also create headroom for better building space, controls and systems to support occupiers' activities. This is all akin to the constantly rising specification of cars at any price point as automotive design and build efficiencies, stemming from the same information modelling approach, continually cut the base cost.

3.11. **Professional services** for the built environment will **expand their range** to add value, partly to compensate for the reduced income available for the (current) standard service offering. Front end consultancy: client advice, briefmaking and design, can become much more sophisticated, as can post-completion service and feedback. Clients will benefit from more suitably specified and managed environments making their activities more effective and their buildings less costly to occupy.

3.12. Both professional services and construction services will become more **internationally competitive.** Professional services are readily exported but the UK has been a high cost location from which to export them. Lowering these costs and increasing service quality will make them more competitive and a substitute for services now often imported for cost reasons. Construction products are harder to move around the world but lowered cost for UK manufacture, coupled with higher quality and attached information potential, will also improve competitiveness. UK advantage will flow from early adoption of BIM and from subsequent continuous improvement.

3.13. The move to **offsite manufacture** of buildings, from the present level of products through assemblies to whole building modules, is fundamentally enabled by BIM, which can also drive automated manufacture. Waste and pollution are reduced significantly, as is risk to health and safety. These social and environmental savings also save consequential economic costs. The advent of additive manufacture, or 3D Printing (ref 6), opens up potential for short-run and one-off items to be economically produced from BIM data. This can be particularly useful in building construction and renovation where a standard component may not always be suitable or available.

3.14. The provision of **software and ICT services** to the built environment market is a growth industry in itself, anticipated to expand by 17% CAGR globally (ref 5) from $1.8bn in 2012 to $6.5bn by 2020, but still only 0.05% of the world construction market. Continuous innovation in applications, services and new technologies lies ahead, creating a new sector within the construction supply chain for which the UK is well suited.

3.15. The growth effect will not come suddenly. Firms typically need three BIM-based projects under their belt before they can outperform previous practice. Multi-firm teams need to play together regularly. There are ten or more method steps up the BIM ladder from start to full Level 2 practice (ref 11). Crotty (ref 12) expects a five year period (to 2016) in which investment is made and new methods learned by the mainstream. After that he predicts unforeseen changes and major productivity improvement. The whole industry could be transformed as

retail was by EPOS, working in an environment of trustworthy, sharable and computable information. Productivity growth will continue as new applications, technologies and services are enabled by BIM. Level 3 working, however to be defined, will arrive as a further step on this ladder.

10 Steps into BIM for a professional firm

1. Acquire BIM software and suitable machines for it
2. Train staff, including for the Information Management role
3. Work to the PAS 1192-2 process and the Digital Plan of Work
4. Develop a practice library of standards, using Uniclass 2
5. Create a BIM Execution Plan for each project
6. Share models on a collaboration platform
7. Use a collaborative form of contract
8. Use the BIM Protocol to the contract
9. Apply Government Soft Landings (if public sector)
10. Provide COBie outputs (if public sector)

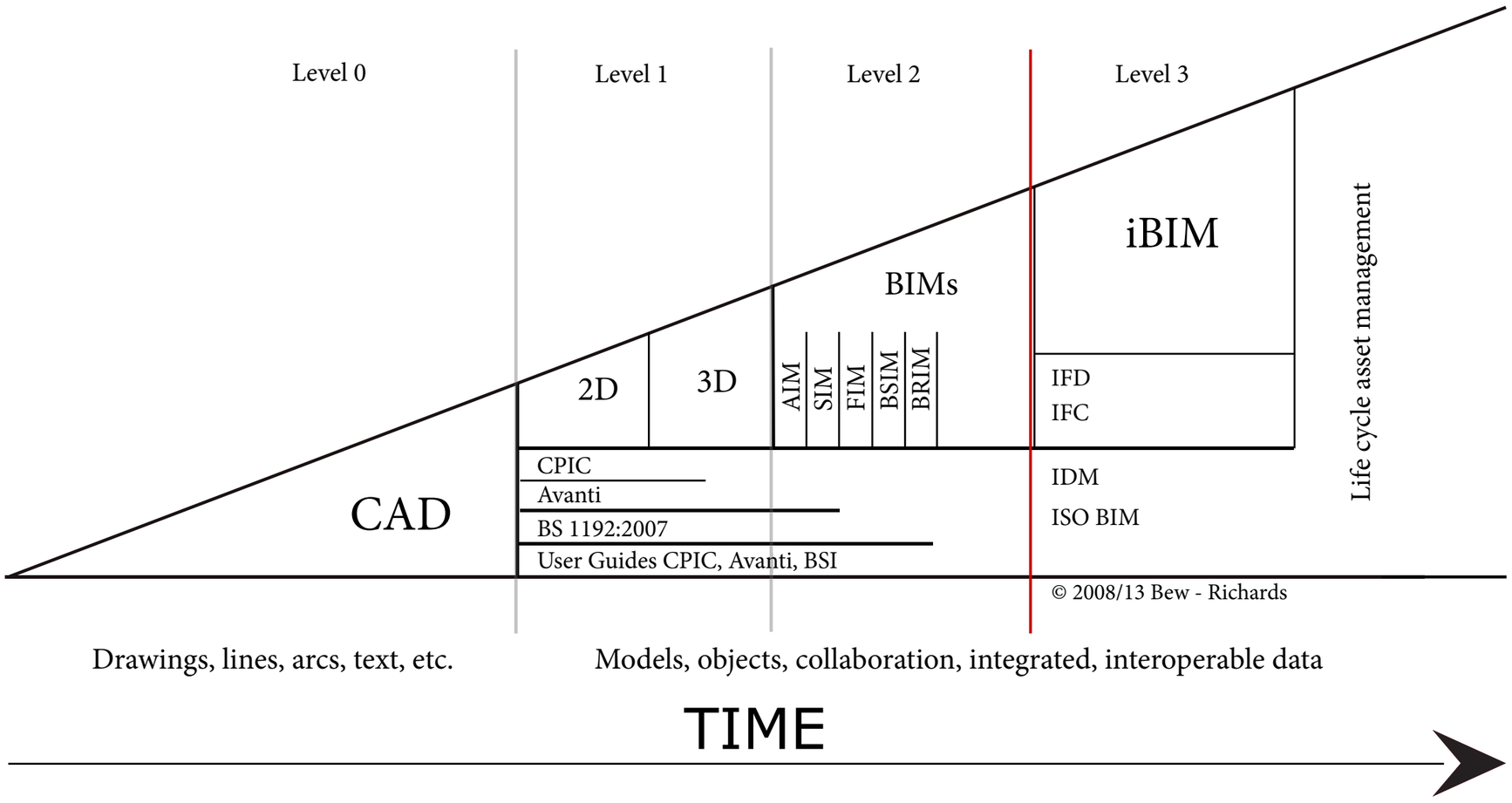
Royal Sussex County Hospital for Laing O'Rourke: Occupied floor plate axonometric

4

The Outlook for BIM development to 2020.

4.1. The government has created an invaluable stepping-stone for the industry in setting the goal of Level 2 working by 2016. Level 2 puts off the difficult changes required to move onto more truly integrated working and encourages people to get started. Leading practitioners are already working beyond Level 2 and early-adopter projects are in progress to prove ideas useful to working beyond Level 2. A vision for what lies beyond Level 2 is needed soon to ensure that methods emerging now will prove durable. Equally, open minds must be retained on what Level 3 is until the options and issues become clearer.

4.2. Level 3 on the Bew-Richards Ramp diagram (ref 13) is envisaged as 'iBIM', an integrated model instead of federated separate ones. This implies that each contributor's inputs merge seamlessly into a single, consistent model environment held on the Web, whilst at the same time the contributions can be identified, tracked and audited. The model contains controls to allow any contributor to access their own aspect and revise it as authorised. Applications can be run in the model for any design, costing, construction or operation simulation. It runs from office to field use so as to serve all members of the supply chain. It is kept portable by not including copies of associated information but just the links to it. The iBIM will be able to include constraints such as local codes and standards, guiding the users. A standard dictionary of terms will have been devised and adopted to avoid ambiguities.



4.3. The Level 3 iBIM will probably live on the Cloud and possibly have its software delivered to users as a service from the Cloud. This will remove the users need for short-life, high-end workstations and fixed annual software costs: users would pay as they use. Protocols for Cloud-based working will need to be worked out to ensure secure management. The use of intelligent agents is likely also, scouring the web for supplies that meet the needs of the design.

4.4. Forms of contract and insurance suitable for integrated team working will need to be ready for Level 3. Today's collaborative contracts, plus their BIM Protocols, will need to develop into ones which can support shared responsibility but also manage disputes. Integrated Project Insurance, currently in early-adopter trials, will be a key factor in making collaborative working acceptable to more clients and suppliers. Insurance probably has a larger role in future construction, allowing the development of insurance-backed, whole-life guarantees to clients.

4.5. The maintenance of a BIM-based industry requires a business model to support the development and maintenance of international Open BIM as a working method with standards, outside of the proprietary vendor environment. Some income must be derived from governments, vendors, and/or users to support an infrastructure: volunteer input has its limits and will hold back progress.

4.6. When Nicholas Negroponte of MIT envisioned computer assisted design in his seminal book of 1973, The Architecture Machine (ref 14), he saw it as the development of machine intelligence. CAD up to BIM has not been intelligent but simply a dumb assistant to manual processes. Now we are entering the Artificial Intelligence (AI) era where systems can make decisions and substitute for human intellectual labour. There is a Level 4 beyond Level 3. Big Data, streaming from the built environment in use, will guide the operation and modification of that environment. A lot of it will be self managing.

4.7. The future of BIM is significantly within the UK's potential to steer. Whilst the USA dominates the vendor and user markets, much of the intellectual horsepower and momentum behind BIM is British and the UK's BIM Policy, Digital Built Britain concept and Open Data approach are world leading. It would be greatly to the UK's advantage to be proactive at government and business levels to exploit our potential as leaders in BIM.

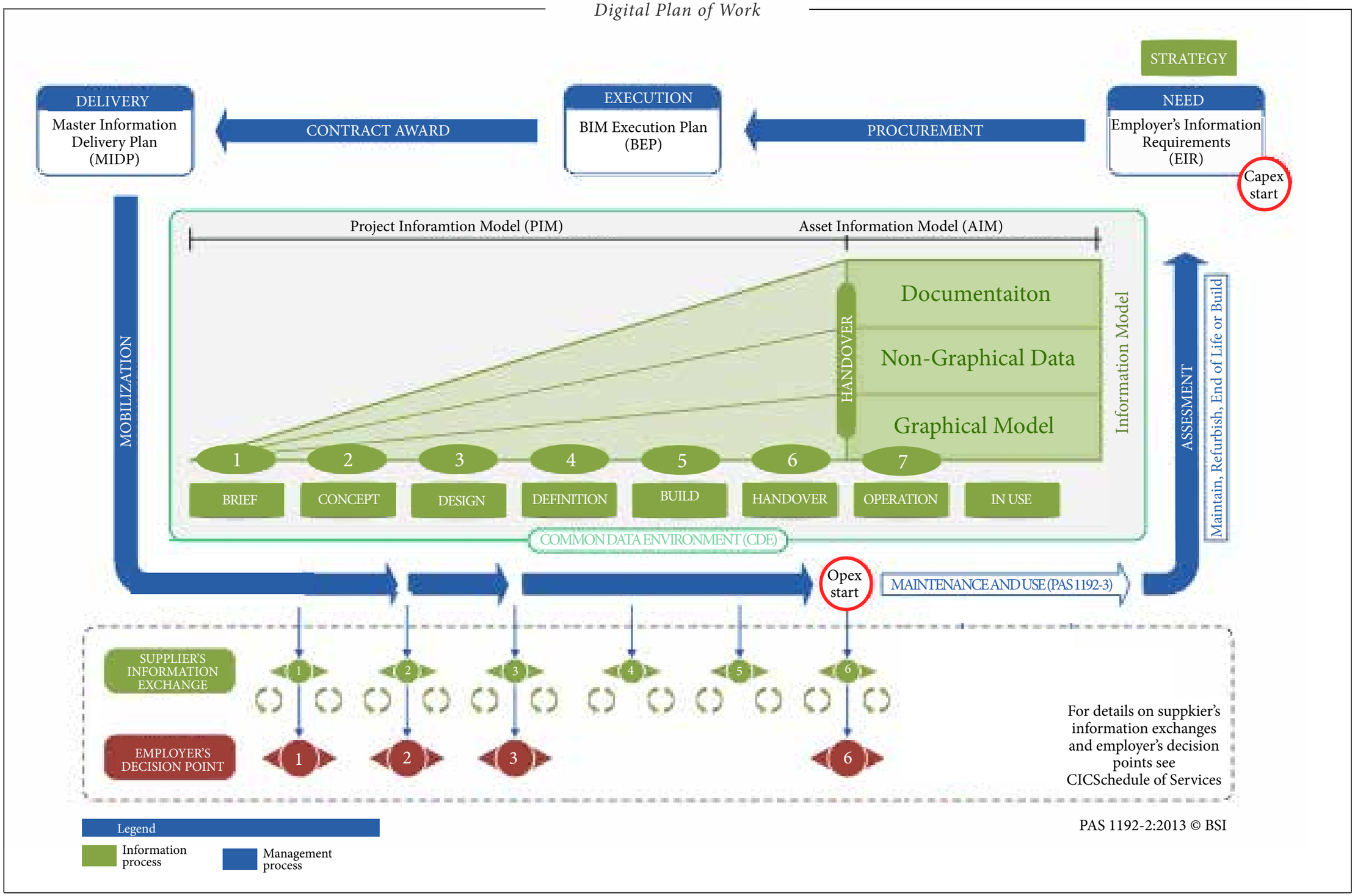
Royal Sussex County Hospital for Laing O'Rourke: Furniture, fixtures and equipment from the model

5

Impacts on the members of the value chain.

5.1. The 2013 Digital Plan of Work of the construction industry, devised for the BIM Task Group by the CIC with its professional institution members, will form the context for wide-ranging changes in practice for stakeholders across the industry. A new plan was necessary not only to make full use of the potential of BIM but to overcome long-standing weaknesses in understanding and practice. The introduction of BIM is being used by the government to drive through changes first called for by the Latham and Egan Reviews of 1994 and 1998, plus some more recent insights, including those mentioned in 4.0 above.

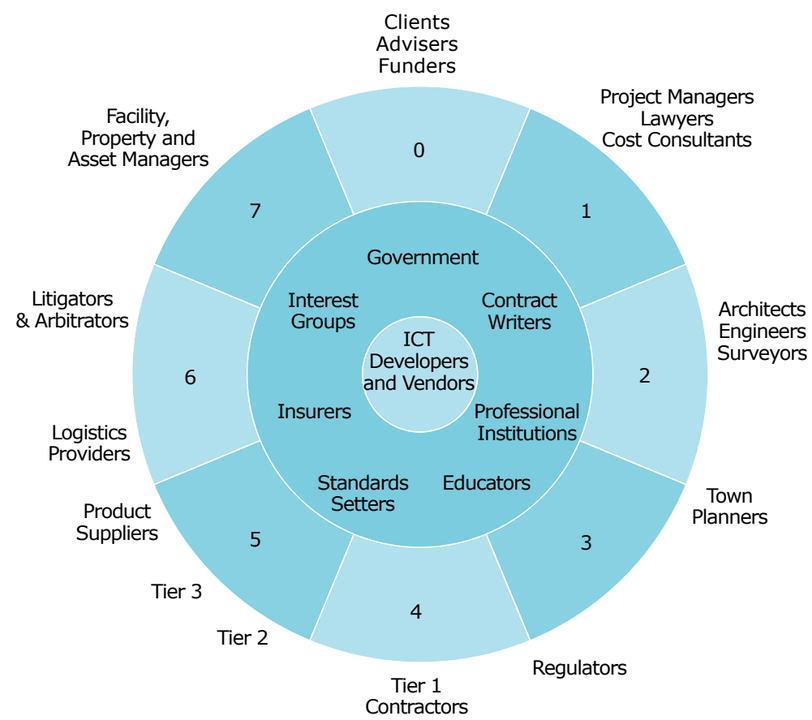
5.2. In summary, the new Plan of Work (ref 15) redefines a project plan as a life cycle rather than a linear plan. Eight stages are identified, starting with Stage Zero in which the need for a project is identified and a business case prepared, based as far as possible on evidence


STRATEGY
DELIVERY
Master Information Delivery Plan (MIDP)
CONTRACT AWARD
EXECUTION
BIM Execution Plan (BEP)
PROCUREMENT
NEED
Employer's Information Requirements (EIR)
Capex start
MOBILIZATION
Project Inforamtion Model (PIM)
Asset Information Model (AIM)
Documentaiton
Non-Graphical Data
Graphical Model
HANDOVER
Information Model
ASSESMENT
Maintain, Refurbish, End of Life or Build
1
2
3
4
5
6
7
BRIEF
CONCEPT
DESIGN
DEFINITION
BUILD
HANDOVER
OPERATION
IN USE
COMMON DATA ENVIRONMENT (CDE)
Opex start
MAINTENANCE AND USE (PAS 1192-3)
SUPPLIER'S INFORMATION EXCHANGE
EMPLOYER'S DECISION POINT
For details on suppkier's information exchanges and employer's decision points see CICSchedule of Services
Legend
Information process
Management process
PAS 1192-2:2013 © BSI

from outcomes of completed projects. Stages 1-6 cover preparation, design and construction up to handover of the building and its maintenance information. Stage 7, In Use, covers operation and the gathering of feedback from use as material for future plan-making. The re-definition of these stages to make use of BIM includes defining the level of development of the work at each stage-end Information Exchange, ready for client decision to progress. The RIBA Plan of Work, the basis for industry project planning since 1963, will be revised in 2013 to fit the Digital Plan of Work (ref 16)

5.3. BIM use affects the nature and quantity of work to be done at each stage. Most significantly, it brings forward work into early stages to define the concept and to develop the chosen design as a BIM. It reduces design workload thereafter as the model provides much of the output needed. The design-build process can still be operated in many different ways to suit clients and suppliers but these ways are novel to a degree and involve learning and changed processes. Roles and relationships change. All stakeholders need to change their work plans and business models to exploit BIM fully. For many this will be difficult and the following review of all stakeholder types around the 'BIM Space' highlights challenges and opportunities across the industry to 2016 and beyond. It reveals where government intervention might be worthwhile to achieve the maximum growth effect from the adoption of BIM.

BIM. The stakeholder ring



5.4. **Public Clients.** The Government Construction and BIM Strategies were created to serve public clients. The working group of central government clients realised that the adoption of BIM-related processes would not work fully without major changes to client culture and practice. These have been set out in the Lean Procurement report (ref 17) and call for a shift to whole-life thinking, outcome-based briefmaking and collaborative working with integrated design-build teams. There has also been much work done on aligning the processes of public clients and those of suppliers. This has produced an insight valuable to all

clients and suppliers: that clients' internal decision making sequences need to be revised to make relevant decisions neither too early nor too late for the construction process. In turn, the stage-end information produced by the supply side needs to provide the material necessary to support the client decision-taking process. Major investment in training and adviser support will be needed to achieve the desired 'Lean Client' behaviours and to spread them across all departments of both central and local government, education and health clients. As one aspect, clients will need to determine the value to them of the BIM-related service changes available from suppliers, both the economies and the service extensions possible: conventions of how much to pay and for what will have to be recast.

5.5. **Corporate Clients.** Companies that build regularly to house their businesses have similar gains to make as do public clients in adopting BIM-based working. Glaxo and BAA were the pioneering clients and their lead has been followed by supermarket chains. Where successive facilities are sought to be built more rapidly and to a constantly higher performance, the tools provided by BIM serve the corporate business plan, also increasing the predictability of outcome. The US concept of Integrated Project Delivery (IPD) (ref 18) is particularly relevant to the regular corporate client. This approach puts the client in the lead with consultants and constructors managed on a BIM basis by or on behalf of the client who retains the prime risk. Speed and flexibility follow, with risk much reduced. There are many clients who have yet to begin their use of BIM however. Business is not generally very skilled in acting as a construction client and now that new skills are needed there will have to be a concerted education effort made. As with public clients, there will need to be a revaluing of the services purchased to suit priorities.

5.6. **Developer Clients.** Developers are very professional construction clients in the main, whether they retain their projects or sell them on at completion. The former are however more likely to see the point of BIM as a whole-life process tool whilst the latter will concentrate on its ability to cut risk, time and capital cost. Because they usually invest a lot of time in design, financing and planning approval before going to tender, developers may well also use BIM differently to public and corporate clients, retaining lump-sum tendering on complete designs as a way of achieving cost certainty and transferred risk. BIM allows much more complete and consistent information to be produced by consultants so that bidders cannot hope to bid low and make profit later from weaknesses in consultant information. Honest bidding is effectively enforced. The revaluing of services purchased will play differently in commercial development: the process has break-points and those who could benefit from the BIM may not get access to it or be equitably charged for that benefit unless that is written in.

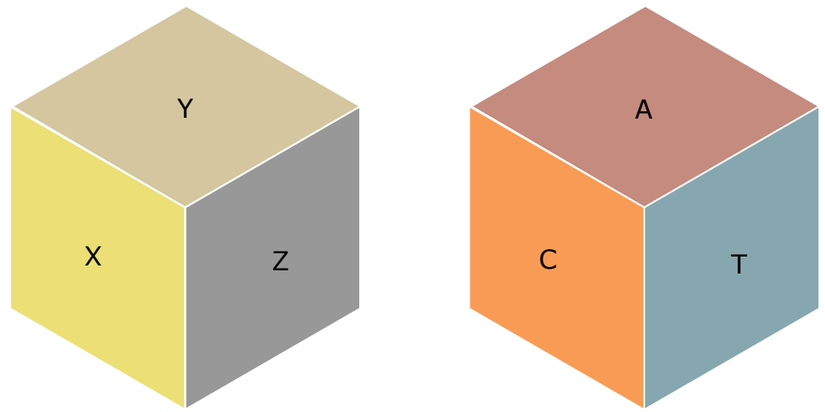
5.7. **Housebuilders** are likely to use BIM in support of their already well developed processes, employing standard elements from project to project. The greater ability to build offsite will attract some. Selling homes through strong visualisation and the ability for buyers to customise the design will prove very attractive. IKEA Kitchens uses a mini-BIM process online which shows the potential.

5.8. **Small and Occasional Clients.** SOCs are often not small but this category includes all those third sector and private organisations which do not have regular experience as clients. This list now includes academies, free schools, sports clubs, charities, lottery grant winners and most office tenants. They have always needed strong advisers and this need will be accentuated to enable them to take advantage of BIM as others will. Education and guidance sources will have to be good.

5.9. **Project managers.** These consultants, who emerged in the last few decades to fill a role not being well enough covered, are often early on the scene to support all kinds of clients who do not carry in-house project leadership capacity. BIM will alter their toolkit as it can support better planning, coordination, communication and auditing. The workload required to deliver previously normal service levels is reduced; project durations can be lowered; risk is smaller. The task of the project manager is greatly assisted but not fundamentally changed by Level 2 working. Level 3 and the rise of the Integrator role will challenge their business model.

5.10. **Cost consultants.** The quantity surveyors' task which began in the mid-nineteenth century as one of measuring a set of architect's drawings and selling copies of the resulting bill of quantities to contractors wishing to tender has been much affected by ICT over the last decades. The bill will now be a rapid by-product of the model (the 5th model dimension), with significant savings available from more precise quantities. The core of the new task will be to identify the benchmark budget to achieve the value sought, plan the allocation of cost across it as design guidance and manage spending through all work stages. The shift to whole-life thinking from a concentration on capital expenditure will challenge the profession to gather much more data and feedback and advise from a wider knowledge base to deliver value consultancy. Some firms are re-branding as asset advisers, demonstrating awareness of the change required.

The six dimensions of BIM



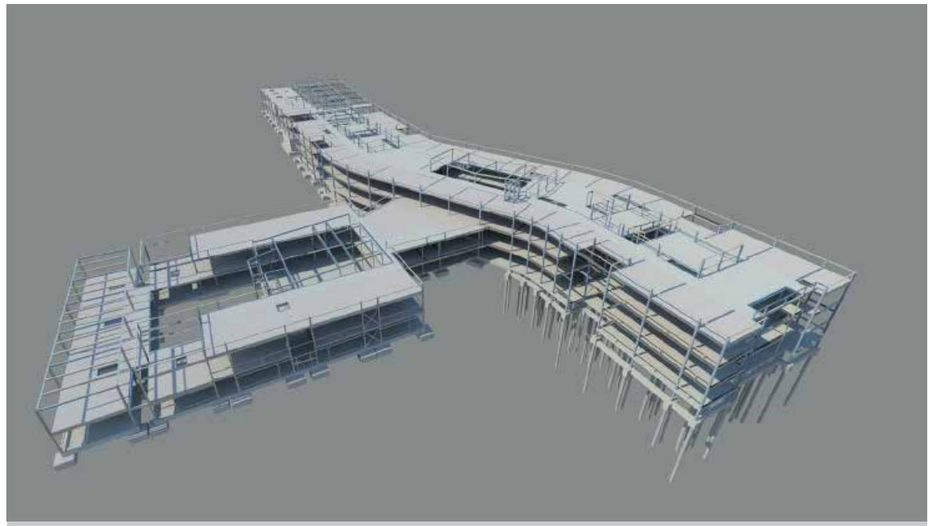
Key: *X, Y, Z - the three spatial dimensions.*
T - the time dimension, for construction sequencing
C - the cost dimension, quantities and rates
A - associated information, including specification

5.11. **Architects and Architectural Technologists.** Architects emerged as a profession in 1834 with their decision to separate from trade. Before that date master builders developed, designed and built. John Nash and the Adam Brothers were amongst the last of these integrated practitioners. This historical note is appropriate because of the emergent view that integration is now desirable again. BIM has a

Alder Hey Children's Hospital, patient room, for Laing O'Rourke

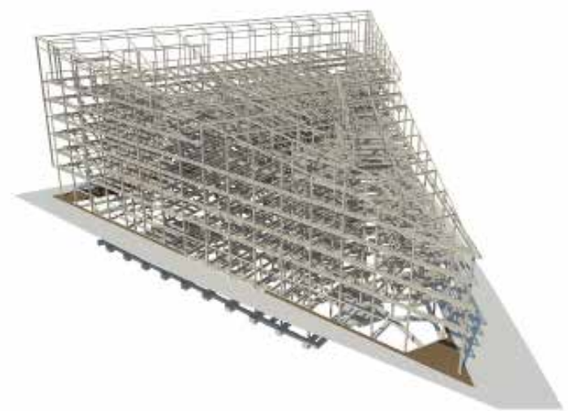
radical effect on architects' practice and some have been early adopters, seeking greater control of design and more competitiveness. The RIBA's 2013 Plan of Work reflects some of the changes: more work is needed at Stage 2 to extract a sound brief and produce a concept model; also at Stage 3 to develop the model technically. After that much less work is needed to document the design or support the site work, just where the greatest effort used to be needed. BIM use in some procurement styles can lead to further division of the task between different types of firm: Client Advisers at Stages 0 and 1; Concept Architects at Stage 2; Executive or Design for Manufacture (DFM) specialists at Stages 3-5; Post Occupancy Evaluators at Stage 7. There is scope for much better briefmaking with stakeholders, given accessible evidence of what works and the new ability to visualise and simulate. The new ability to store and retrieve elements of design could sort out practice approaches into those needed for essentially standard building types (eg mass housing, warehouses), those for customised standard types (eg schools, health facilities) and those for largely one-off projects (eg town centres, museums, remodellings).There will be a need for more attention to good process in the office and scope for architectural technologists to take a larger role: their prowess in ICT matters and document management will serve firms well (see 7.1). The practice of off-shoring documentation work to low-labour cost countries, common before the financial crash and BIM, is probably extinct now. Indeed there will be much more seeking of export work. Trained staff is proving a major asset and salaries and competition for BIM experts have risen sharply. Overall, the opportunities for and challenges to the architectural profession are considerable and new business models are needed.

5.12. **Civil and Structural Engineers.** Engineers emerged in the late 18th and 19th centuries to create canals, roads, bridges and railways, using the new principles of physics and materials science. Nat-



Dixon Allerton Academy. Structure

ural forces became calculable and new materials could be used after their properties were understood. Civil (as distinct from military) engineers are the leaders of infrastructure work whilst structural engineers provide consultancy support to building design and construction. Many contractors trained as C&S engineers. Computing has affected the two professions substantially since its introduction, greatly reducing the calculation task and allowing better analysis. BIM was taken up by structural engineers very early as one can move directly from a design model to the fabricator cutting steel by numerically controlled machine, an approach that is still some way off for other specialisms. Civil engineers are later into BIM as it was initially aimed at building design. They use Geographical Information Systems (GIS), a parallel digital concept for holding information about land and assets. Civil BIM is emerging fast however, blending previously separate analysis tools into it. Artificial intelligence is already used: for example road alignment tools have safe curve and slope rules built in. Structural engineers will find that early stage work increases with BIM use but that later stages are much lighter. Specialist structural contractors may take more of the work also. Engineers' spare capacities may well be called upon to lead BIM management in teams and multi-discipline firms. Engineers have been commercially aggressive in consolidating their businesses globally and absorbing other disciplines into super consultancies to meet the huge world demand for infrastructure in particular. These powerhouses are now rivals to Tier 1 contractors for the Integrator role across projects and programmes. As BIM and programme management tools reduce risk so the professional style of leadership becomes an alternative to the contracting style.



Technology and Innovation Centre, Strathclyde University

5.13. **Building Services Engineers.** The mechanical, public health and electrical disciplines grew out of trades devoted to installation. There have always remained designer-constructors in the field and

Government Soft Landings (GSL)

"Soft Landings" was defined by Cambridge University and its consultants Mark Way and Bill Bordass in 2005. It set out to ensure that its new buildings were well handed-over and easy to operate. Facility management requirements become part of the brief, with enhanced duties at commissioning and handover, followed by team members in residence in the building for a period after occupation, to iron out problems. GSL adds digital tools and stresses feedback through data flow and in-use evaluation. It also seeks successful outcomes for users, not just good building physics.

there are related product-based specialism which remain designer-constructors (eg for lifts and sprinklers). Practitioners move between consultancy and contracting. Free-standing professional consultancies as a result are often tasked with limited services, the bulk of the work being included with the subcontractor design. This has not been wholly successful as sustainability has put more emphasis on the conceptual stage and its integration with the architectural and structural design of buildings. There has also been a long-standing issue about performance of services in use: systems have often not been fully commissioned, nor well operated and maintained, due to the fragmented procurement pattern. BIM and Soft Landings (ref 19), coupled together in the government BIM strategy, are likely to alter the service landscape for the profession. Briefing will now include operational aspects and the commissioning and post-handover operation of the facility will link back to the designers and makers. More workload will come at Stages 2 and 3, less at 4 and 5, more at 6 and new services at Stage 7, In-Use. Design simulation and analytical tools will need to migrate to a BIM basis, interoperable with other professions' models. Continuous checking of designed performance is likely to be possible, rather than a major check at a late stage. Client satisfaction is likely to improve considerably. Buildings are getting much more ICT installed nowadays, for both building control and occupier business support. Previously separate technologies now share the Internet Protocol and it is likely that specialist firms will undertake both base building and occupier system design and installation. The sensor-based Internet of Things will make building control much more sophisticated.

Services Coordination in a hospital

5.14. **Landscape Architects.** The landscape profession goes back to the eighteenth century and the landed estates. It now uses GIS technology to work with landform, infrastructure and location information, but will need to embrace BIM for hard landscape and involvement with buildings and civil works. BIM and GIS convergence is part of the current developmental need. Profession-specific modelling software is now available.

5.15. **Other design professions.** Interior and graphic designers, lighting and acoustic specialists, fire and fabric engineers, geotechnical and traffic engineers, all will need to migrate onto a BIM platform to continue to collaborate with the design and construction team. Their current computer-based techniques will need to be rewritten to run on a model, or feed from and back into a model. They will most likely follow the lead of the architects and engineers with whom they usually work.

5.16. **Building Surveyors.** Surveyors are a very old profession: Christopher Wren was described as Surveyor to the Kings Works before he became known as an architect. The term now describes an expert in construction maintenance and repair, including measuring sites and buildings to convert them into drawings. BIM was not seen as relevant to work to existing buildings until recently when laser point-cloud surveying emerged as a rapid way to capture existing buildings and landforms into digital format. BIM tools are now centrally relevant to Building Surveyors in their asset management tasks: they will also be using COBie as will Facility Managers.

5.17. **Town Planners.** The planning profession is under several stresses currently, some political and some technical. It emerged out of architecture at the start of the twentieth century but has become a largely managerial discipline. Development control entails processing the design of proposed development through several filters, including currently the sustainability performance of the design. Arguably such subjects are Building Regulation matters requiring non-planning skills. BIM offers support to the planner in enabling designs to be checked automatically against constraints. Singapore has been operating combined planning and building regulation processing on an automated basis for ten years. The planning rules need to be formatted for this purpose and UK rules have a performance and discretionary approach rather than a 'deemed to satisfy' one. Consideration needs to be given to the potential for a BIM-based approach for the UK, as part of a review of the machinery of planning control. BIM can also speed up the creation of guidance plans and design codes to allow plan-led control to illustrate acceptable development to applicants as well as to be a basis for automated checking. One issue to be explored is the timing of planning permission in the BIM Plan of Work. As most design work is now done by Stage 3, the classic point for planning application, developers will be loath to commit to such investment before knowing that they can get permission. Increased use of illustrated outline permission at Stage 2 would be logical, with details reserved to Stage 3 before any start on site.

5.18. **Building Regulators,** including for Health and Safety. Reviews are currently in progress to streamline the several channels through which proposals must pass to get technical clearance of design and intended operation. This review should include how to put the process on a BIM basis. As mentioned above, checking for compliance with codes and regulations can be automated. Manual checking is quite poor but BIM could do it 'perfectly'. Rule-based codes can be applied easily but performance-based requirements need simulation tools. These exist for designers and could be used by regulators too. Fire modelling and hazard simulation are examples. Progressively, design codes could migrate into the design software to pre-regulate it. Automation must not be done in a way that stifles innovation but the potential progressively to direct most of the inspectorate to enforcement work would be welcome. Lack of compliance on site remains an issue. Shifting to a BIM basis would be radical for the regulators but a much better use of resources.

5.19. **Standard setters.** Standards have a major role to play in the success of BIM as a growth factor. A flurry of new ones is in progress at the British Standards Institution to describe the documentation process and operational processes. New product information standards are coming in from the EU this year. The interoperability of BIM products is a worldwide issue as applications to sit on them pour out of software houses. There needs to be a concerted push to ensure that good standards emerge rapidly and are accessible to everyone. ISO Technical Committee 184 is now the focal international working group. The international acceptance of British Standards is a factor in UK construction exports. Rival standards regimes have advanced across the world, creating landscapes which favour the services and products of those countries. The UK needs to make its standards equally well known and acceptable in the markets we hope to serve.

5.20. **Tier 1 Contractors and Construction Managers.** Main contractors, or Tier 1s as they are often now called, have an expanding role under BIM. The rewards of integrated team working, where all the members except the client are led by the Tier 1, are well demonstrated in early BIM examples. The role of 'Integrator', leading a team from day one, is open to Tier 1s who can master the management of consultant-client interaction. Other voices call for 'early contractor involvement', meaning calling in the Tier 1 before design is advanced but after the briefing and concept stage. Only some developers, who have years of work to do before being ready to build, are likely to keep a traditional distance from Tier 1s until after Stage 3. BIM puts new emphasis on supply chain management, favouring Tier 1s who have stable subcontractors who understand their process. It also opens up the FM role further, for Tier 1s to extend their offer past occupation date. However, BIM closes down the besetting sin of recent years: contractors under-pricing their bids to win, followed by clawing back profit from claims based on the always imperfect information provided by consultants. BIM dramatically raises the completeness and consistency of consultant information, forcing tenders which must look like the final account. Early BIM users in the USA report substantial cost reduction potential from reduced risks in the information provided: up to 30% less rework and waste (Tocci Construction). Timescales come

Gain-Pain Sharing

Instead of clients bearing the cost of over-runs, subject to claims against suppliers, Gain-Pain Sharing incentivises the whole team to better a target. Once the contract target cost is set, any undershoot 'Gainshare' is allocated between clients and supplier team and any overshoot 'Painshare' likewise, up to agreed limits.

down by 5-15% also, aided by the 4th dimension of the model, the time sequence of construction which can be simulated and rehearsed, removing surprises. More profit can come from reduced risk and from 'Gainshares'. Site performance can also benefit from far fewer needs to request additional information and from the use of fast mobile communications and tablets to support model access.

5.21. **Tier 2 Contractors.** The specialist contractors who provide structural frames, services, and envelopes deliver most of the site value in a project. Under BIM-based working they can find themselves in more stable relationships with Tier 1s, but also closer to consultants when Tier 1s do not enter early. Some may win more Stage 2-3 design work to do though most concentrate on Stages 4-5. Offsite manufacture rises in importance, with modules supplied to sites. Turnaround time for orders can fall by three months on large projects. Similarly, Tier 2s can ask for their subcontractors to provide more complete assemblies, not just component parts. There is concern in some innovative Tier 2s that their IPR can be stolen more easily through BIM as it is easy to copy files that show how innovative approaches work. Attention is needed to mitigate these concerns.

5.22. **Tier 3 Contractors and below.** The fragmented nature of the industry is made clear when the full list of suppliers to any building project is published. The Tier 2 contractors get componentry and sub-assemblies from a host of sources and many of these are also built up from Tier 4s and 5s inputs. The ICT systems that Tier 3s use to make their elements are usually pre-BIM and need to be recast into interoperable BIM terms. Tier 1s and 2s will put pressure on to get this, with software vendors' help. Integrated supply chains with stable membership, as in the car and aerospace sectors, will benefit the vulnerable lower tiers of the industry.

5.23. **Product makers and suppliers.** About 50% of the capital cost of any building is in products: materials, machines or systems provided as standard or customised. This is the most manufacturing-like part of construction and the most profitable part of the industry. Of the c£50Bn UK spend on products, about £12Bn is imported, whilst about a further £6Bn worth is exported, largely of lighter interior items. The

trend is for an increasing import proportion as UK capacity is retired in the face of low demand. EU suppliers dominate and the EU has just imposed the Construction Products Directive to enforce standard information provision with products. This set out to cover the need for environmental data but pre-dated the need for it to be in BIM format. Major UK suppliers report problems with developing their information provision as they are being asked by each Tier 1 for different formats. This is highly counterproductive and a standard form needs to be imposed to enable progress. SMEs need help to get started at all. Specifiers are now being offered BIM tools to select suitable products, such as 'NBS Create' from the RIBA. There could be return to designers nominating preferred products through such channels. One threat to product suppliers is the parallel with the effect of EPOS on suppliers to the supermarket trade. From being the most profitable part of the retail world before EPOS, product makers have become the underdogs. Retailers commodify products and bulk buy with high quality information about demand whilst product makers fight back with more and more diverse offerings. One wholly new product potential arising from BIM is the concept of additive manufacture, or 3D Printing. A component can be made one-off or in short runs by a tool steered by a 3D model of the product. This will allow unusual designs to be created competitively, without transport costs.

5.24. **Logistics providers.** Those who assemble and transport products and materials to sites are well placed to benefit from BIM's addition of data. They already optimise loads and journeys using ICT but will increasingly be carrying items with coding corresponding to the BIM components they are. Waste in deliveries should be reducible further, plus the potential for unloading in sequence directly into place. The larger assemblies likely to come from suppliers will shift some of the logistics role to those assemblers. Offsite manufacture poses challenges to logistics firms to integrate with those fixed 'sites' as well as with the transient ones.

5.25. **Information and Communication Technology suppliers.** The ICT element of the built environment industry is a relatively young but with explosive potential. It is growing globally at 17% CAGR to meet the demand for BIM and related tools, training and support services. Software writers have an open field to devise new applications and many of these may turn out to change the roles and task of parts of the industry. There is a major need to establish standards for interoperability, completing the IFC/IFD/IDM concepts laid down by buildingSMART (see 5.32.1). The Semantic Web can also be applied to enable translation between standards. Convergence of the GIS and BIM standards is needed, plus extension of the capital building phase into operation through the Internet of Things concept where sensors using the Internet Protocol report on the state of occupation, fabric, systems and environment, allowing better control and compiling data for feedback and analytical mining. ICT installations in buildings, for the base building and the occupiers, will undoubtedly become more sophisticated, limited only by the creativity of the sector. This is clearly the growth strongpoint of the industry, though its absolute growth will probably be dwarfed by the growth it stimulates in the rest of the industry and economy.

5.26. **Insurers.** The role of the insurance industry in built environment and its professional services is a long-standing one but could be transformed by BIM. Integrated design-build-operate, the paradigm being pursued by the Government Construction Strategy, requires integrated insurance offerings. The present pattern of each of the myriad players in a project insuring themselves against all risks leads to lack of collaboration to solve problems, and lack of protection of the client who can claim (from the professions) only on proof of their negligence. It also leads to gross over-insurance, with 2/3rds of premiums being expended on fighting claims rather than on protecting clients. Trials are in progress of an integrated insurance product which would cover the risk of price escalation as well as of defects after completion on the basis of all parties being covered by a policy held by the client. This is a radical concept not yet used in other countries and requires more work by the insurer. The market is reluctant to offer it so far for lack of evidence of workability. Integrated BIM-based working requires integrated cover if we are to progress beyond Level 2 BIM as responsibilities and contributions become harder to separate. There is also the potential for insurance to cover in-use performance. Registered Social Landlords and commercial developers can already insure to fix their maintenance costs based on an insurer's database of whole-life building performance. This is moving to a BIM basis as well. An integrated insurance market needs to be nurtured and developed to overcome issues and doubts. It could become a powerful support to the export of UK integrated design-build-operate services worldwide. Export of integrated project insurance to the USA, which does not yet have a product to support IPD, could be possible. There is even the potential for 'guaranteed buildings', a concept currently shied away from. Fitness for purpose, backed by insurance, would be a breakthrough offer to clients but would need to overcome large perceived difficulties. The Japanese industry effectively offers this to its domestic market, based on long-standing customer-contractor relationships and integrated design-build supply chains, but without insurance cover. BIM may reduce conventional risks so much that radical moves to eliminate the rump of it become thinkable.

Integrated Project Insurance

IPI is being used in an early-adopter government project to prove the value of shared insurance to the use of BIM. Instead of each party carrying a separate policy, the client carries one master policy which covers them against all risks, including that of cost overrun beyond an excess figure. The insurer approves the design and waives recourse to the parties. On this basis the team comes together to solve problems rather than flying apart. Shared risk in a Level 3 BIM would be covered.

5.27. **Lawyers, adjudicators and arbitrators.** The one segment of the construction industry which does not look upon BIM as a growth opportunity is the construction law fraternity. The industry has historically been a goldmine for contract writers, dispute handlers and the courts. Fees for legal services can equal those for design and the profitability of consultants and contractors is often eaten by servicing disputes, many of them caused by imperfect information. BIM Level 2 will remove some of this workload. Level 2 is defined in such a way as to put off the day when fundamental change in contract needs be discussed. It leaves conventional liabilities, insurances and forms of contract in place. To progress to Level 3 we have to expect a far lower level of conflict in the process. 'Perfect' self-checking documentation and integrated insurance would remove the source of a lot of disputes. Execution may still be imperfect and humans will always be human, but the diversion of client, consultant and constructor resources to the legal profession will be lower, perhaps much lower over time. Level 3 services will embrace the whole life cycle of built environment, not just the construction project, and new contract forms will be needed. Even at Level 2, lawyers will extend services to act as facilitators of team formation, agreements and the BIM Protocol, as they did with partnering. What partnering needed to succeed was BIM and this risk-managing collaboration concept will probably return to favour in supply chain relationships. Intellectual Property Rights is an important area to tackle, with measures required to prevent unlicensed appropriation of innovations and design ideas.

5.28. **Contract writing bodies.** These bodies, principally the Joint Contracts Tribunal (JCT) and the authors of the National Engineering Contract (NEC), are aware that expectations are changing because of BIM. They foresee a wide spread from small projects using the tools of today to large ones wanting new approaches. The drive to collaboration faces the urgent need for self-preservation in harsh market conditions. Whilst Level 2 BIM is based on not requiring new forms of contract, the early adopter projects are trialling existing collaborative forms which are at the fringe of current usage. JCT Constructing Excellence, PPC 2000 and NEC3, in order of unfamiliarity, are seen as the vanguard of the contracts of tomorrow. Learning from use of these, together with use of BIM, is expected to allow a vision of future, Level 3 needs to emerge.

We Wish

"Please do not let lawyers in the industry turn BIM into the next excuse for endless long clauses in consultancy agreements and schedules of amendments to JCT contracts. You might sprinkle some fairy dust of understanding on us about what BIM actually is and why it does not need 7000 words of dense type to make it work"

Ann Minogue's New Year column in Building magazine, Jan 11th 2013

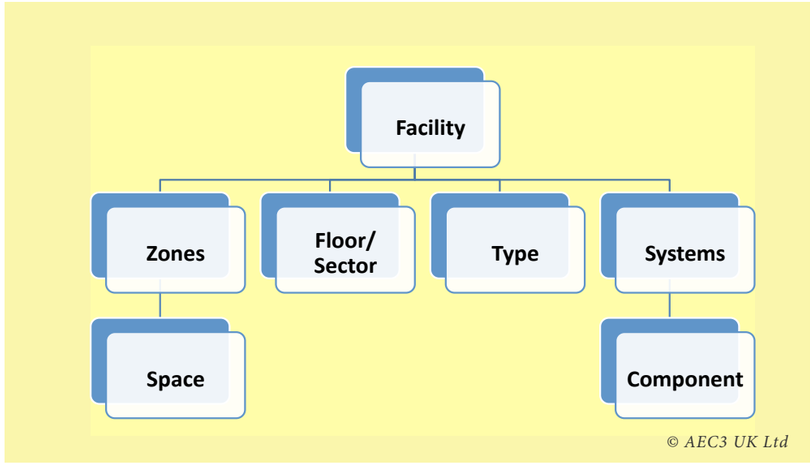
Capella Tower, Glasgow, for Wilson Bowden, managed property

Liverpool ONE, for Grosvenor, Paradise Street: managed property

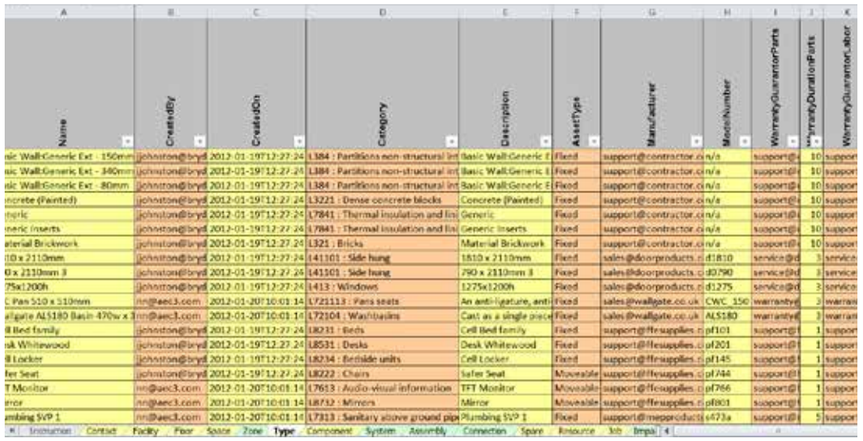
5.29. **Real Estate Consultants.** The professionals who support commercial investment, development, letting and management as well as those inside corporations as their estates mangers will find BIM tools powerful for them. They can now know far more about assets and their performance and present advice in an interactive way. COBie will prove valuable to a group that is not a CAD user, adding to its toolset to assess and optimise the corporate estate and its fit to needs from year to year. Investment models, development equations, rental and service charge discussions and likely repair obligations may be supported by innovations in the available data and in insurance products. Growth in effectiveness is in prospect.

5.30. **Funding Institutions.** The finance houses are a major part of the built environment ecosystem. Commercial development depends

COBie Structure



COBie spreadsheet for product types



Name	CreatedBy	CreatedOn	Category	Description	AssetType	Manufacturer	ModelNumber	WarrantyGuarantorParts	WarrantyDurationParts	WarrantyGuarantorLabor
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sic Wall:Generic Ext - 340mm	johnston@bryd	2012-01-19T12:27:24	L384 : Partitions non-structural int	Basic Wall:Generic E	Fixed	support@contractor.c	n/a	support@	10	suppor
sic Wall:Generic Ext - 80mm	johnston@bryd	2012-01-19T12:27:24	L384 : Partitions non-structural int	Basic Wall:Generic E	Fixed	support@contractor.c	n/a	support@	10	suppor
ncrete (Painted)	johnston@bryd	2012-01-19T12:27:24	L3221 : Dense concrete blocks	Concrete (Painted)	Fixed	support@contractor.c	n/a	support@	10	suppor
neric	johnston@bryd	2012-01-19T12:27:24	L7841 : Thermal insulation and lis	Generic	Fixed	support@contractor.c	n/a	support@	10	suppor
neric Inserts	johnston@bryd	2012-01-19T12:27:24	L7841 : Thermal insulation and lis	Generic Inserts	Fixed	support@contractor.c	n/a	support@	10	suppor
aterial Brickwork	johnston@bryd	2012-01-19T12:27:24	L321 : Bricks	Material Brickwork	Fixed	support@contractor.c	n/a	support@	10	suppor
10 x 2110mm	johnston@bryd	2012-01-19T12:27:24	L41101 : Side hung	1810 x 2110mm	Fixed	sales@doorproducts.c	d1810	service@d	3	service
0 x 2110mm 3	johnston@bryd	2012-01-19T12:27:24	L41101 : Side hung	790 x 2110mm 3	Fixed	sales@doorproducts.c	d0790	service@d	3	service
75x1200h	johnston@bryd	2012-01-19T12:27:24	L413 : Windows	1275x1200h	Fixed	sales@doorproducts.c	d1275	service@d	3	service
C Pan 510 x 310mm	nn@aec3.com	2012-01-20T10:01:14	L721113 : Pans seats	An anti-ligature, anti	Fixed	sales@wallgate.co.uk	CWC_150	warrantye	3	warran
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ll Bed family	johnston@bryd	2012-01-19T12:27:24	L8231 : Beds	Cell Bed family	Fixed	support@ffesupplies.c	pf101	support@	1	suppor
sk Whitewood	johnston@bryd	2012-01-19T12:27:24	L8531 : Desks	Desk Whitewood	Fixed	support@ffesupplies.c	pf201	support@	1	suppor
ll Locker	johnston@bryd	2012-01-19T12:27:24	L8234 : Bedside units	Cell Locker	Fixed	support@ffesupplies.c	pf145	support@	1	suppor
fer Seat	johnston@bryd	2012-01-19T12:27:24	L8222 : Chairs	Safer Seat	Moveable	support@ffesupplies.c	pf744	support@	1	suppor
T Monitor	nn@aec3.com	2012-01-20T10:01:14	L7613 : Audio-visual information	TFT Monitor	Moveable	support@ffesupplies.c	pf766	support@	1	suppor
rror	nn@aec3.com	2012-01-20T10:01:14	L8752 : Mirrors	Mirror	Moveable	support@ffesupplies.c	pf801	support@	1	suppor
mbing SVP 1	nn@aec3.com	2012-01-20T10:01:14	L7313 : Sanitary above ground pip	Plumbing SVP 1	Fixed	support@mepproducts	s473a	support@	5	suppor

Information | Contact | Facility | Floor | Space | Zone | Type | Component | System | Assembly | Connection | Spare | Resource | Job | Impact

on them and public service building has involved them through the Private Finance Initiative and now PF2. Traditionally it has been banks that provided money for projects prior to completion, with long term funds replacing them once the construction risk is past. This is because there is conventionally a significant up-front risk during construction that the planned cost and time will not be achieved. As BIM-based working settles in, this risk will fall. Banks are likely to favour BIM-powered projects and may offer better rates for them. Long-term funds may be prepared to enter the market at construction stage if risks are managed down sufficiently. This would be a major growth effect as banks are weak lenders now and long-term funds need sound investments to supply returns. Monitored projects will reveal if things can change sufficiently.

5.31. **Asset, Property and Facilities Managers.** This profession group has major growth potential arising from BIM. They are conventionally separate from the construction world, not involved in briefing and not making much use of the information from construction in their subsequent management. They have been largely unaware of the interest in BIM for that reason. Soft Landings, linked to BIM, brings these two worlds together. Managers will be expected to engage with project briefmaking, providing knowledge from projects in use and setting the operational and maintenance brief. They will receive a commissioned building with data ready for them to use in operation and will be expected to provide in-use reports on actual operating performance and expenses and on occupier performance as enabled by the building. Achieving Opex targets and occupier outcome goals will become part of the job, with the data streams from the managers and their systems. A culture of 'no-fault feedback' will need to be devised to prevent stakeholder obstruction or fear of blame from inhibiting the process.

5.32. **Professional Institutions.** The various institutions which support the professions in the built environment area are challenged by the move to digital working. It creates a new knowledge base of buildings in use, with whole-life data flow requiring a new concept of professional knowledge and practice. It also raises the issue of why what should arguably be an integrated process needs so many separate societies, each claiming a part of the work for its members. The roles which the BIM process highlights, Client Adviser, Integrator, Model Manager, etc, do not belong to any particular profession. Many sen-

ior people in professional firms are not graduates of that firm's core discipline and members of construction firms can be from almost any discipline. The question posed by government over the years remains: "Can you not combine?" The reasons for so many separate profession bodies, more than in other countries, stem from the way we in the UK have so far dealt with the handling of a wide body of knowledge. From the Royal Society of the 17th Century, where polymaths ranged across all that was known, we progressively divided up into fields to cope with the explosion of new knowledge. The concept of a profession and its values come out in the 19th Century to ensure competence and probity in each specialism. Medicine has had to deal with a huge proliferation of specialisms but has fewer bodies than the built environment. The pattern here reflects the fragmentation of the industry. Computing is making a new paradigm possible: that broad knowledge may once again become master-able by individuals. A BIM structures and retains huge bodies of knowledge and applies artificial intelligence to them. It and the tools it supports reduce the need for some of the intellectual effort previously deemed essential. It is likely that the professional bodies will be galvanised by the arrival of BIM to review their services to members and to equip them for the new world. There will be turf wars about the new roles created: the RICS could try to become the 'Profession of Information' rather than of the Land. The RIBA will see the architect's design role strengthened by the coordinating and communication power of BIM. Its BIM products, the National BIM Library of generic objects and 'NBS Create', are powerful tools. Multi-discipline consultants will vie with contractors for the Integrator role on major projects. The professions will all have to steer their education providers, reorienting courses for the new reality.

The Construction Industry Council, in which all professional institutes are members, could be the facilitator for collaboration and coexistence and even for eventual mergers.

5.33. **Educators.** The built environment professions and trades face a major educational challenge in adapting to BIM. Educating undergraduates is important but only part of the story; two and a half million office and site personnel need to be re-educated en masse. The BIM Task Group has identified three levels of training: operator level, for users on projects; team management level, for those organising and leading teams; and strategic level, for those leading firms. One problem highlighted is that most universities have retreated from what they deem to be 'practical training' into 'education for life'. They justify this as concentrating on long-term capabilities, leaving practical matters to be learned and re-learned on the job. This is not realistic with regard to BIM as digital working represents a sea-change in approach to professionals' roles and skills. The greatest challenge is that of education in 'silos', with each discipline self-contained. This is antithetical to the systems approach now needed and possible. Cross-discipline approaches must be devised and curricula modified. Arguments that curricula are already too crowded must be tackled: in the USA the experience was that making time for BIM crowded out time for the subject of sustainability. Both are vital and synergetic elements of built environment education.

5.34. **Interest Groups.**

1. buildingSMART. BIM was devised by enthusiasts working together internationally. The so-called International Alliance for Interoperability (IAI) worked on the essential ideas from 1996. This society, now called buildingSMART, remains the keeper of the flame of interoperable BIM. The success of BIM has however strained the concept of a voluntary society as its developer. Well capitalised vendors have taken the development lead and have resisted the interoperability concept to try to retain users within their proprietary approach. building SMART UK has just been merged into BRE to give it greater capability, but there is much still to be done to establish standards and methods on an open basis to enable all the world to work together. Government will need to put its weight behind the effort, and to act inter-governmentally with interested nations.

2. OpenBIM. This group of Tier 1 contractors, vendors and academics was set up in 2012 to explore the effective use of BIM. In particular they wanted to find ways to make the variety of software available interoperate. They have recently reported on trials of using the IFC format to produce COBie data (ref 20). They are all keenly interested in applying BIM interoperably and call for the IFC format to be formally required as part of the BIM policy.

3. Constructing Excellence. This pan-industry group was formed to implement the Egan Review agenda in 1999 and in 2005 was merged with 'Be, collaborating for the Built Environment'. It is now part of the BRE Trust. CE has concentrated on fostering collaboration and best practice, measuring results against key performance indicators. BIM as a tool for more effective collaboration is of central interest to Constructing Excellence, providing the engine of trustworthy information which eluded earlier attempts to build lasting cooperation. Its national spread of groups is one channel for education and it will play a monitoring role on the government early adopter projects.

4. The fourth key interest group is the sustainability or 'green' movement in its various forms. The sustainability interest sees BIM as part of its toolkit to produce a low-carbon, low-waste economy. BIM is not just about economic efficiency as it supports better value in many ways: for example, better analytical tools for design; offsite production, which BIM supports, creates less waste and better working conditions as well as saving time and cost. There are those who see BIM and sustainability as somehow opposed or alternatives. They certainly fight for academic time. They are however allies: better tools for design, construction and operation aid sustainability. The link between Low Carbon and Low Cost needs to be maintained in the mind of government and industry.

Royal Sussex County Hospital for Laing O'Rourke: The project in its urban setting

6

Growth through BIM: the strategy.

6.1. BIM will unleash growth in UK construction, and in the wider economy. A 'Growth through BIM' Strategy would ensure that the effect is maximised and brought on as quickly as possible. This report confirms that most of the policies being followed by the BIM Task Group are worthwhile parts of any 'Growth through BIM' Strategy. The Task Group is developing the Level 2 methodology and spreading knowledge of it in a very effective way, to ensure that the mainstream construction industry can understand and use Level 2 BIM by 2016. It is also working towards some of the needs of Level 3. The Growth through BIM (GtB) Strategy must also be read as part of the Government Construction Strategy and now as part of the Construction Industry Strategy being developed. The GtB Strategy should work across the whole Built Environment as a more effective construction industry will lift the sector and all its stakeholders. The growth effects of investment in construction are well known (ref CBI) and any stimulus to investment arising from industry improvement will have multipliers across the economy. This advice however sticks to its remit of explor-

ing growth effects within the built environment industries which could arise from BIM adoption. Recommended actions for government and industry are set out below in a sequence reflecting the project life-cycle, Stages 0 to 7. They begin with actions important to the on-time achievement of Level 2, followed by that of Level 3, then by measures to promote exports of UK construction services and products.

Completing Level 2

6.2. **Interoperability standards.** Many in the industry are still uncertain about the policy on interoperability, due to the perceived reluctance of vendors to deliver it for their own commercial reasons. Government has been clear that its data policies all require open standards. For BIM this means the IFC concept which allows any software platform to share a model. The incomplete IFC standard needs to be completed and cyber-security concerns need to be addressed. The Open BIM message needs to be reinforced.

6.3. **Product information standards.** Guidance is being issued to product suppliers via the Digital Workplan to provide the information required by the EU Construction Product Directive (ISO 15804) on a BIM basis. A single standard for the information should be agreed by industry, over-riding diverse contractor preferences for standards of their own. This will overcome current supplier reluctance to begin providing BIM-based information. Information should be required on a Uniclass2 basis, the classification system most suited to BIM.

6.4. **Alignment of BIM and Sustainability strategies.** Government BIM and Sustainability strategies need to become aligned. They developed separately but are synergetic. In particular, concepts of whole-life value ('Totex' = Capex plus Opex; Totcarb = Capcarb plus Opcarb) need development. Government Soft Landings crosses the boundary between capital and revenue spending and the new Workplan includes feedback from the operation stage. The UK has the basis for a competitive offering of whole-life, design-build-operate services but needs to create a home market for these to support export efforts.

6.5. **Preference for stable teams.** Manufacturing productivity keeps advancing because engineering teams stay together and learn. The use of Framework Agreements to pre-qualify integrated supply teams should favour stable design and buildability teams which invest in learning from project to project. This will raise BIM competences faster than in teams constantly re-formed as is now the norm.

6.6. **Maturity checks and competence qualification.** Industry should promulgate a model for firms' and teams' progression into Level 2 BIM competence. BIS should endorse such a scheme. This could then be used to measure the maturity of a firm and team and to provide a competence qualification scheme. Some measurable standards are deemed necessary to prevent incompetent use of BIM undermining its reputation and potential.

6.7. **Cost-benefit distribution.** The industry should undertake an analysis of the way costs and benefits of Level 2 BIM use fall across the client-supplier-user chain to assist in re-setting assumptions about sensible service and compensation patterns. At the next level of detail, analysis should be done of the distribution of cost and benefit created in professional services when working to the new Workplan and on L2 BIM. Obsolete rules of thumb on appropriate compensation levels and payment points need to be re-set. Benchmarks should be able to be circulated without raising concerns at the Office of Fair Trading.

6.8. **Levels of Detail and Definition (LoD).** The concepts of the Levels of Detail (geometric information) and of Definition (data maturity) to be reached at the end of each workstage are of major significance and should be fully explained to all stakeholders. These ideas in UK terms are essential to support the analysis of value created at stage points and to support handoff of work to another player where such changeover is part of the procurement path.

6.9. **CIC Services 2.** The CIC Scope of Services, 2nd Edition (ref 21), should be supported as an electronic tool for clients and their advisers to plan and allocate roles and tasks to all participants in a project, as required by the BIM Protocol to the contract. 'CIC Services 2', ready during 2013, is based on the Digital Plan of Work and provides back-to-back descriptions of all contributors' work, tailored to the chosen procurement path. This should become teaching material for Lean Client courses, as well as CPD for all contributing suppliers.

6.10. **Intellectual Property Rights.** Issues related to Intellectual Property Rights (IPR) in BIM should be resolved. At present some contributors are reluctant to participate without a better way to prevent their original ideas being captured, before or after contract, for later use by others with access to the BIM. In a Level 2 context, where each contributor's work is on a separate model, this work is identifiable. In a Level 3 BIM it must still remain so and the ways in which other industries solve this issue should be studied. The question 'Who owns the BIM?' needs a clear answer too: for example, clients cannot claim to own the intellectual property in their building's BIM and still claim that authors are liable for faults. Clients simply have a licence to use a BIM, to build and operate the project in question. Authors retain the IPR and the responsibility for quality. Royalty payment to authors for extension of rights is a reasonable concept. Clients also need to be able to issue libraries of standard assemblies and components to the market for their projects.

6.11. **BIM for Infrastructure.** BIM tools for infrastructure work are being developed by vendors with users to enable the infrastructure sector to progress as well as the building sector. Geospatial tools need to become aligned with BIM concepts so that they can interoperate. For example, Google Earth could show site data as a 'first-survey' tool. Data standards for team-client communication also need improvement.

6.12. **Cloud Computing.** Using the Cloud to store and share BIM data will save cost and energy and should be developed and promoted. Safeguards and management tools need creating to make this a secure approach. Supplying BIM software and related applications from the Cloud, as 'Software as a Service' (SaaS), should also be promoted. This will greatly reduce the entry cost for smaller firms, replacing capital need with charges by the hour of use, and removing the need for upgrades for each user machine as the software develops.

6.13. **Software Industry.** There is considerable scope for UK software developers to ride the BIM policy and develop tools to realise the digital ambitions of clients, designers, builders, manufacturers and operators. The government has committed to work with the Technology Alliance on an incubator for ICT start-ups in the BIM field (ref 22). Ideas can come from practitioners across the built environment and pro-active customers will drive successful applications. This is a new subsector of the industry and one which should grow rapidly.

6.14. **Town Planning timing.** The town planning process should be reviewed to facilitate giving permissions at Stage 2 of the Workplan rather than at Stage 3. With investment in relevant design concentrated into Stages 2 and 3 by BIM, clients require earlier certainty that a proposal will be accepted before full investment. Stage 2 BIM proposals will be more effectively presentable than were conventional Stage C designs. Detail can still be reserved to Stage 3.

6.15. **Statutory Approvals.** The building regulations, health and safety, and planning processes should be reviewed to see if a system similar to that in Singapore can be used in the UK. There, BIMs are submitted for checking by computer against the regulations and rule-based planning policies. Errors or issues are flagged and once cleared, the project is considered passed for construction. Final processing takes a matter of hours. In the UK the planning process has consultative as well as technical content and only the technical can be fully handled this way. Automation of this aspect of building inspectors' work would free the workforce to concentrate on site compliance, an area requiring far more resources than it currently gets. Large time savings would flow, plus a reduction in uncertainty and an increase in site construction quality.

6.16. **Facility Management.** The Facility Management profession needs particular support to develop its methods into BIM-compatible form to meet the needs of Soft Landings and of outcome-based brief-making. The creation of a standard, PAS 1192-3, will be a useful focus for this effort. The necessary development of user-friendly COBie tools will also assist. Independent building performance appraisal and a blame-free feedback culture will need to be created for all stakeholders benefit or honest information will not appear.

6.17. **Capturing progress.** A programme should be set up to capture the effects of new Procurement, BIM and GSL policies on the performance of the industry. This would identify change in appropriate key performance indicators. Some of the gains will be in cost terms and there will be a need to separate the effect of other economising moves from those attributable to use of BIM. Where extra value has been taken, as with the use of Government Soft Landings (GSL), that should be noted, offsetting capital cost outcomes but capturing operating cost results and carbon performance. In-use data should be related to the benchmarks assembled by CarbonBuzz (ref 23) to reveal the effects of GSL.

6.18. **Awards.** An award scheme should be devised or adapted to recognise exemplary projects. The Prime Minister's Award for Better Public Building should be reserved some time after 2016 for BIM-based projects which have good Post Occupancy Evaluation results. The timescale for awards would go back two years compared to a scheme for newly completed work but this is now necessary to judge actual outcomes against planned ones.

Roche Pharmaceuticals HQ, Welwyn, 2005, completed early and under budget; thanks partly to BIM

Defining Level 3

6.19. **Level 3 Vision.** A vision for what will become Level 3 BIM should be developed by a Task Group. The business case for client benefit above that at Level 2 will be one issue. The programme for its introduction should be set once a consensus is achieved. This consensus will need to be internationally recognised to be worthwhile and the UK's recently expressed desire to be a world leader in BIM will need to be turned into action.

6.20. **Completion of the interoperability agenda.** Assuming that the Level 3 vision includes interoperability on an IFC basis, investment must be made in the completion of the interoperability development agenda, including the IDM (Information Delivery Manual) and IFD (International Framework for Dictionaries) standards. This long list of developments and tools to complete requires major acceleration to avoid proprietary approaches becoming entrenched. This too is an international consensus matter but cannot be left to voluntary effort any longer.

6.21. **Level 3 commercial arrangements**. Contract and insurance forms suitable for Level 3 working need to be developed. The work in progress now on early-adopter projects will need to be replicated and analysed and solutions produced to meet emerging requirements. The insurance industry will need substantial attention to be convinced to offer suitable products.

6.22. **Big Data analysis.** The flow of data from buildings created on the basis of the BIM policy, and of data captured on existing stock by advanced means, needs to be handled in the context of the 'Digital Built Britain' and 'Smart City' Industrial Strategy concepts. The analysis of this data has to lead to a flow of guidance to future project definers so that outcomes can be more realistically defined and achieved in light of outcomes. This will progressively raise the effectiveness and efficiency of the built environment.

Bridge Academy, Hackney, for UBS and DfES / DCFS, 2008. An early BIM project

Promoting UK exports.

6.23. **Support to EU construction policy.** Promotion of UK interest and business through leadership of BIM development suggest that the UK offer assistance to the EU in its currently planned policy for construction. An alliance with the presently advanced nations could help concerted progress. An EU conference is expected in 2013 to define the construction policy and it does not currently feature any BIM dimension. A pro-active stance by the UK could be welcomed.

6.24. **Promotion of British Standards.** British standards need to be better promoted internationally to enable UK construction exporters to offer our nationally approved work. This is not just about BIM standards but about the whole set of BSI built environment standards which support product use, design and construction approaches. It would be ideal for target market countries to be persuaded to set up their own BIM mandates on the UK model and thereby create scope for UK firms to assist them and to win work there.

6.25. **Global development of BIM.** If the UK wishes to put its construction industry in the most competitive position globally, it should not only develop the skills of the domestic industry but offer leadership of the development of BIM to the international community. Our devising of the Bew-Richards Ramp model of levels 1, 2 and 3 is widely admired. Putting flesh on the concept of Level 3 whilst also helping other countries to adopt their versions of Level 2, would be strong positioning for UK firms to demonstrate leading-edge practice. Exporting BIM-based work is at present biased towards the front end of the potential as the full scope depends on collaborators in the receiving country joining in use of the model. This 'technology transfer' is not yet widespread and should be supported.

6.26. **Education priority.** All these actions presuppose that the UK built environment industries are being re-educated effectively and that competencies are building up. Action to ensure this might include the creation of online inter-discipline courses. These could be aimed internationally too. Cultural change, (back) to collaborative working and to good process in practice, needs constant reinforcement through client channels. The UK industry needs to be rewarded by increased profitability as part of the rise in productivity: savings must not be entirely captured by clients. Early adopters will do best and a flow of their case studies will be the best material for learning. As noted in 6.16 above, nationally captured material will be the best resource. One aim of all the BIM developments is to re-position construction as an advanced industry, attractive to bright youngsters and providing global careers.

Appendices

7.1. Survey of Chartered Institute of Architectural Technologists members' use of BIM, November 2012.

CIAT polled their members in November 2012 for this research. Most members work within architectural firms. The response was as follows:

75% understand the principles of the BIM process

72% possess BIM software in their firms

62% of firms have BIM-trained staff

32% use current Information Management standards (eg BS1192)

38% have a BIM library of details

44% use NBS generic objects in modelling

29% use NBS Create, the BIM Specification tool.

68% exchange models with their consultants

34% exchange models with the contractor

44% exchange models with Tier 2 Specialists

62% import BIM product data

17% use a BIM Execution plan

14% use a BIM Protocol

15% provide FM information in COBie format

40% claim to use BIM collaboratively (less than claim to share; see above)

31% use collaborative forms of contract (NEC3, PPC2000, JCT CE)

36% find BIM working costs less

60% say that in their firms Technologists are responsible for BIM practice

41% have completed more than 3 projects on BIM

62% (of a small sample) has noticed a change in the amount of work done

65% (of a small sample) has noticed more time being made for design

59% believe that they are getting better quality work from BIM use.

Appendices

7.2. Interviewed sources.

The following authorities were consulted, mainly by interview but also from conference presentation or publication:

- Cal Bailey: Marketing and Sustainability director, NG Bailey (Tier 2)
- Phil Bernstein: Vice-President, Autodesk (Vendor)
- Mark Bew: Director, ECS. BIM Task Group chair; buildingSMART UK chair.
- Kathryn Bourke: owner, Whole-Life ltd (consultant)
- James Brayshaw: Customer and Markets Board Director, Ordnance Survey
- Peter Caplehorn: Technical Director, Scott Brownrigg. British Standards sector chair.
- Stuart Chalmers: Technical Research Officer, RIBA
- David Churcher: owner, Hitherwood Consulting. (consultant)
- Ray Crotty: owner, C3 Consulting
- Andrew Eastwell: Chief Executive, BSRIA
- Roy Evans: BIS/CIC
- Paul Fletcher: co-founder, through-architecture (consultant)
- Noble Francis: Economics Director, Construction Products Association
- Helen Garthwaite: Head of Construction Law, Taylor Wessing
- Bill Gloyn: Partner, Jardine Lloyd Thompson Speciality (insurer)
- Christopher Groome: Business Manager, building SMART UK.
- Malcolm Harbour CBE MEP: European Parliament
- Bridget Hardy: PuREnet
- Brian Johnson: Chairman, Europe, Aedas (architects)
- Graham Kean: Head of Global Client Solutions, EC Harris (built asset consultant)
- Alastair Kell: Director of Information and Technology, BDP (design consultant)
- Anne Kemp: Director, BIM Strategy and Development, Atkins (consultant)
- Hans Koggelmann: BMVBS (German Construction Ministry)

Appendices

- Prof. Steven Lockley: Research Director, BIM Academy, University of Northumbria
- Patrick MacLeamy: Chair of buildingSmart Intl and of HOK (architects).
- Adam Matthews: Industry manager, government affairs, Autodesk (vendor)
- Chris Millard: Director, Head of System Integration, Balfour Beatty (Tier1)
- Alan Muse: Director of Built Environment Profession Groups, RICS
- Nick Nisbet: owner, AEC3 (BIM consultant)
- Peter Oborn: RIBA Vice President, International
- Nelson Ogunshakin OBE: Chief Executive, ACE (consultancy group)
- Bill Price: Director, Systems and Technology, Costain (Tier 1 and UKCG)
- Steve Race: BIM Regional Ambassador, CIC.
- Simon Rawlinson: Head of Strategic Research, EC Harris
- Mervyn Richards OBE: owner, MR1 Consulting (BIM consultancy)
- Deborah Rowland: Head of FM, Government Property Unit
- Prof. Tom Schleifer: Arizona State University
- Marilyn Standley: BIFM Task Group chair.
- John Tebbit: Industry Affairs director, Construction Products Association
- Don Ward: Chief Executive, Constructing Excellence
- Richard Waterhouse: Chief Executive, RIBA Enterprises.
- Kim Vernau: Chief Executive, BLP Insurance

With thanks to BDP for the BIM images in this report. Other sources are credited alongside the image.

Appendices

7.3. Documents referenced.

1. Be Valuable, a guide to creating value in the built environment, Richard Saxon, Constructing Excellence, 2005.
2. Industrial Strategy: UK . Sector analysis. BIS economic paper 18. 2012.
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8. Design Intelligence magazine, Vol 18, No 5, Sept/Oct 2012.
9. World Architecture 100, 2013. UBM
10. BIM Gateway. RIBA-CPIC-Central St Martins, 2012.
11. BIM Demystified, Steve Race, RIBA Publishing, 2012
12. Impact of BIM on the Construction Industry, Ray Crotty, Spon, 2012.
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Appendices

7.4. Background of the Author.

Richard Saxon CBE is an architect and urban designer, practicing now as a client adviser at Consultancy for the Built Environment. He has a career-long interest in inter-discipline working and the improvement of the construction product and process. He was a partner, later director, at BDP, the international multi-discipline practice, from 1977 to 2005, chairing the firm between 1996 and 2002. BDP is an early adopter of BIM and provided images for this report.

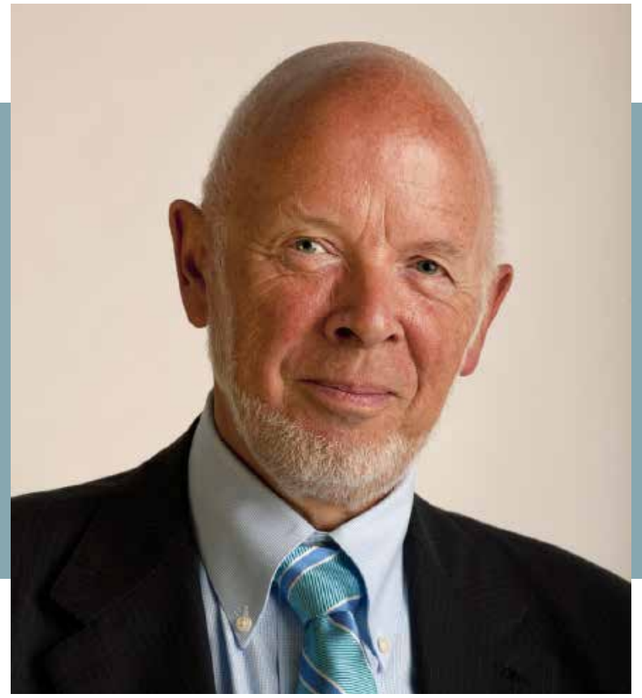

Photo- Morley von Sternberg

From 1994 he was involved in the follow-up to the Latham Review, chairing the Good Practice Panel of the Construction Industry Board. He joined the Reading Construction Forum, a private reform group, in 1995 and became its chair in 1999. He merged it with the Design-Build Foundation to become 'Be - Collaborating for the Built Environment' in 2002 and continued as chair until merging Be into Constructing Excellence in 2005. He published 'Be Valuable, a guide to creating value in the built environment' (ref 1) in 2005. Richard has been Vice-President for Practice at the RIBA and President of the British Council for Offices.

He is currently on the board of the Construction Industry Council, responsible for Research and Innovation.

He was awarded the CBE in 2001 for services to architecture and the construction industry. www.saxoncbe.com

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