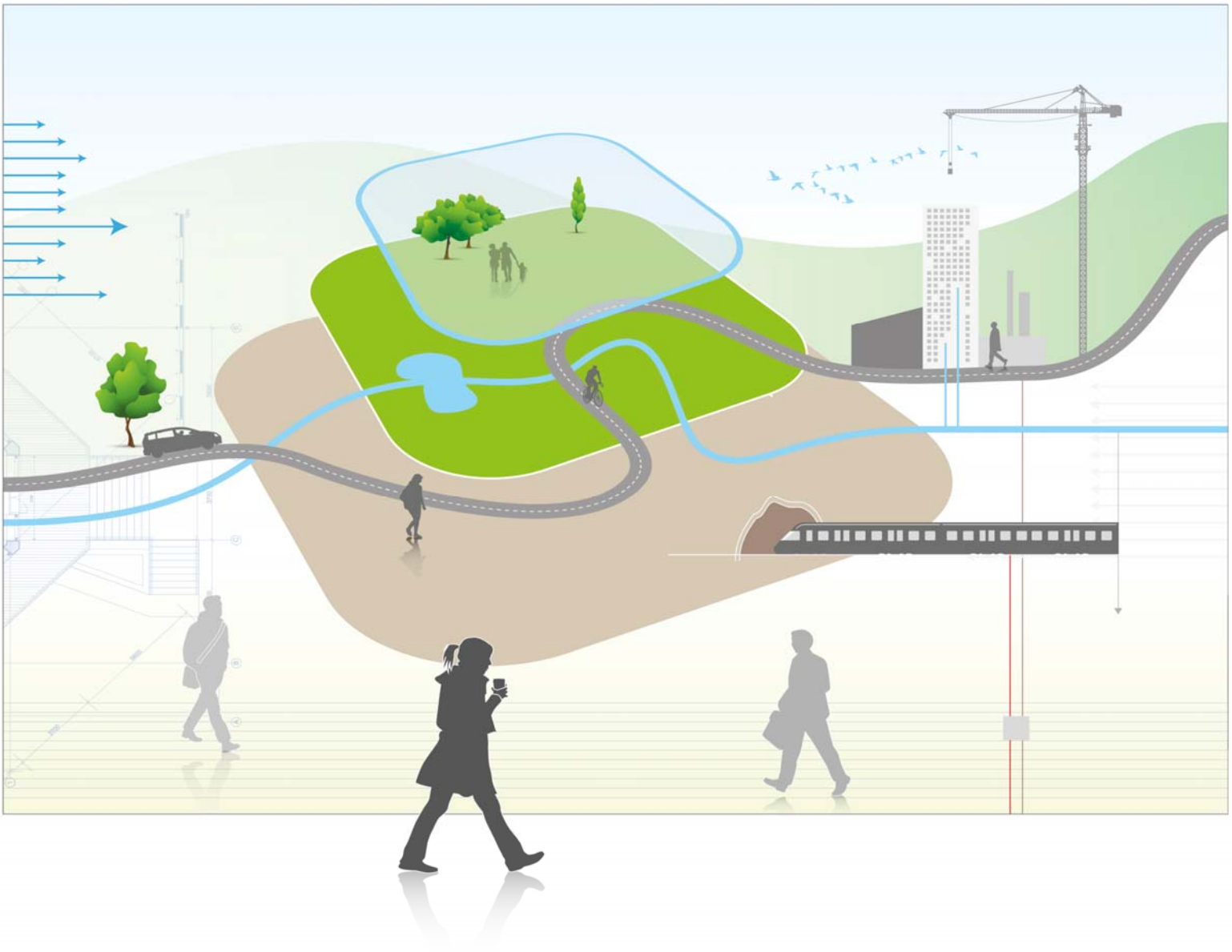
BiM

Management for value, cost & carbon improvement



A report for the Government Construction Client Group

Building Information Modelling (BIM) Working Party Strategy Paper

March 2011

CONSTRUCTING EXCELLENCE in the built environment

UKCG

Construction Industry Council

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Appendix

1. Purpose

The purpose of this document is to brief the Construction Clients Group of the progress and findings of the BIM Industry Working Group.

This Working Group was invited by BIS and the Efficiency Reform Group from the Cabinet Office to look at the construction and post-occupancy benefits of BIM (Building (Asset) Information Modelling & Management) for use in the UK building and infrastructure markets.

The document describes the Working Group's recommended strategy to deliver a structured Government / Sector capability to increase BIM take-up over a five year horizon as part of a joined up plan to improve the performance of the government estate in terms of its cost, value and carbon performance.

2. Recommendations

The recommendations of the Working Group have been made on the basis of a consensus view of all the Group's members: to adopt the "Push-Pull" strategy described in section 4.

We recommend supporting the "Push" supply side of the industry to enable all players to reach a minimum performance in the area of BIM use in five years.

This is balanced by a "Pull" from the client side to specify, collect and use the derived information in a value adding way over a similar timescale.

Key specific recommendations supporting the strategy are:

1. *Leave complexity and competition in the supply chain*
   As a public sector client with responsibility for a diverse and complex portfolio, it is clear that the viability and appetite for a complex infrastructure is both low and inappropriate. There is a mature and competitive market in the UK construction industry and they should be given the opportunity to respond.

2. *Be very specific with supply chain providers, they will only provide that which is asked for*
   The supply chain has become very adept at producing information for the delivery of specific parts of an asset. Issues arise not generally in the individual businesses but where they interface with others or have to deliver a composite set of information from across the supply chain. The contract requirements must be specific regarding deliverables and responsibility for delivery.

3. *Measure and make active use of outputs*
   Make sure that the government client makes use of the information it has asked for, specifically for ensuring key decisions are supported by verified information, but most importantly post occupancy where the potential benefits of information management are clear. The information supplied by the supply chain must be used to drive strategic decisions and demonstrate transparency during the delivery and operational phases of the buildings life.

4. *Provide appropriate support infrastructure*
   A level of investment is required to provide a simple enabling infrastructure for this process. The technology and support involved is no more complex that systems already in use in the UK public sector, such as the planning portal, OCG procurement systems and paperless open borders systems successfully deployed in the last decade.

5. *Take progressive steps*
   We have recommended a series of small but significant steps to enable these techniques over a five year period. A gradual adoption is requested of the supply chain to allow for technology, training, legal and cultural changes to be effectively communicated and adopted on both supply and client side.

6. *Have a clear target for the "Trailing Edge" of the industry*
   It is clear from a healthy open market that there is innovation and opportunity in the sector. From investments already being made by key suppliers, the leading edge of the industry is busy understanding and implementing these processes. It is the trailing edge that needs help and clear

targets. The recommended target is for all projects to be delivering project information at "Level 2" of the maturity model. A communicative approach similar to the analogue to digital television transmission processes is anticipated here to ensure no suppliers are unduly penalised.

3. Aims and Objectives of the Working Group

The Working Group was set up in the spring of 2010 and is supported jointly by OGC, Construction Sector Unit and Electronic and IT Services Unit at BIS. The Working Group draws in representatives from the construction sector, its client base and software suppliers.

The team involved are identified in Appendix 1 and thanks must go to the individuals and their respective organisations for their time and energy in the production of this strategy. The interim report, which was accepted on 16 September 2011, set out the objectives of the Working Group:

- *Identify how measurable benefits could be brought to the construction and post-occupancy management of assets (buildings and infrastructure) through the increased use of BIM methodologies*

- *Identify what the UK Government as a client would need to do to encourage the widespread adoption of BIM approaches to improve project delivery and operational performance, particularly in the areas of demonstrating improvement in cost, value and carbon performance*

- *Review international mechanisms and, in particular, the US Federal Government's five year programme which have encouraged BIM adoption elsewhere and to make recommendations on their lessons for the UK over a similar time horizon*

- *Assess the potential of Government policy on BIM to assist the UK consultancy and contractor base to maintain and further develop their currently strong standing in international markets*

During the process of developing the strategy, rather than attempting to define BIM, the Working Group defined a hypothesis: a scenario that would deliver an environment whereby the Government client would have an estate that was "smarter and better" equipped to face a low carbon economy, with associated reductions in delivery and operational costs and in carbon emissions. This hypothesis is described in Appendix 2.

The Working Group further looked at the UK's general position in this market and identified that with focus we could place the UK in a very strong position to lead the world market in delivering products, services and education in the Smart Building and BIM enabled construction economy.
The UK design and construction industry is facing unprecedented market pressure both in the domestic and International market, it is in these leading edge and value adding capabilities that we have the most potential to maintain and grow our position.

We also have international leading academic institutions that are keen to support both at home and abroad our exploitation of this market. However, universities must collaborate just as the industry does itself and be led by individuals that can bridge the gap between innovation developed by academia and the practicalities of industry.

We have already demonstrated very significant savings derived from adopting the BIM approach. Evidence regarding the increasing fall in construction productivity with respect to other (non-farming) industry is published (see the BSi Investors Report in Appendix 18), BIM can significantly improve this. However BIM is but one part of an overall improvement strategy and due cognisance should be made to other related techniques including "Offsite Manufacturing" and "Lean" techniques which if harnessed in a "joined up" approach will lead to even more dramatic improvements in the industries performance.

The strategy outlined in this report is consistent with recommendations in the Infrastructure Cost Review, with regards to a consistent pipeline of work, effective project governance and smart procurement. Supported by pull from Government this change can be delivered. The UK industry is capable of significant step changes such as those made in the area of health and safety. What the industry requires is the focus of consistency to allow the market to respond to a common demand. This strategy provides just that focus without introducing any new technologies. We are asking the Government Construction clients to focus on a

consistent approach which will generate a consistent demand for the market to address. This will drive a critical mass of improvement upon which we will build over the five year period, by which time we expect all suppliers to the Government Estate to be capable of operating at Level 2.

The November 2010 report by the Low Carbon Construction Innovation and Growth team found BIM to have the greatest potential to transform the habits and eventually the structure of the industry. Industry players were charged with determining the appropriate use of BIM and creating protocols for future working. Government advised to mandate BIM on all central projects in excess of £50m. The Working Group however believes there is evidence to support much wider BIM application.

4. The BIS BIM Strategy

The hypothesis is by design non-prescriptive in its definition. For example it doesn't say "you must use BIM". It does however identify exploitable 'information' as the key driver to enable improvement.

The Working Group has identified the two key variables that matter in terms of performance: Whole Life Cost and Carbon Performance; and it is the decision process made around these key variables that we have concentrated our efforts on improving. To enable correct decisions to be made, timely accurate information (data) must be made available. This removes the need to make assumptions and enables an effective and transparent decision making process to take place.

To enable the delivery of this information the client side and the delivery side must be aligned both in terms of expectation and capability. This is addressed through the application of a "Push – Pull" strategy.

There are two strands to the strategy which define the routes the Working Group is pursuing:

1. *"Push" Element*
   The first strand is a "Push" element which looks at the supply chain and methods by which we could make it easier for them to make use of approaches such as BIM more easily.

   There are many vendors in the market all with their offerings purporting to be the best BIM solution; there are many in the supply chain who are at differing points in the maturity curve, and all think that their flavour of BIM is the answer to all.

   There is also a dearth of guidance, training, materials and common processes available to offer consistent advice to the processes, data definitions or deliverables specifications.

   The proposal is package products, standards, guides and training to support clear simple delivery. Packages will be identified by their maturity as described in Appendix 3.

2. *"Pull" Element*
   The second strand to the strategy looks at the client "Pull" and how the Government client should be very specific and consistent about what it specifies. This includes the need to specify a set of information (data) to be provided by the supply chain to the client at specific times through the delivery and operational life of the asset. See Appendix 6, 9 & 11. This would rely on the careful definition of what data deliverables would be needed and when, linking in to the standards and specification process above. This data delivery would have the dual benefit of ensuring:

   - Complete information sets are delivered on time, enabling commercial checks and handover information delivery
   - Consistent digital handover information is delivered, enabling access to the design, costs, carbon and performance of the asset

In discussion with the US GSA (General Services Administration) team the Working Group discovered a number of parallels. In adopting the US approach the Working Group hopes it has not only "anglicised" it, but also has been able to avoid some of the shortcomings and pitfalls identified by the American team during the implementation of the GSA standard. This close collaboration with the GSA team has led to an "Alliance" being formed between HMG and the Federal team. Details of this are in Appendix 4.

5. Issues, Barriers & Solutions

Whenever change is identified barriers are cited and the development of this strategy has been no different. Many issues are cited as a barrier to integrated team working. BIM, if correctly deployed, can however become a key enabler of the integration process and gives a unique opportunity to make the type of step change that open transparent reuse of digital information has brought to other industries such as retail and manufacturing.

To investigate these issues we engaged seven working groups with senior industry representation and leadership to explore the issues and report back with solutions available and approaches to delivering solutions if required during the mobilisation phase of the programme.

5.1 Exploiting Digital Capabilities

To simplify and aid understanding a maturity "Level" index has been developed which can be used to articulate groups of technology and processes and their inherent capabilities. It is a key recommendation that all public procurement should be carried out at Level 2 or higher by the conclusion of the five year strategy. A full description of the maturity roadmap is included in Appendix 3.

5.2 Legal, Contractual and Insurance

The Legal and Contracts working group has concluded that little change is required in the fundamental building blocks of copyright law, contracts or insurance to facilitate working at Level 2 of BIM maturity. Some essential investment is required in simple, standard protocols and service schedules to define BIM-specific roles, ways of working and desired outputs.

Looking forward to the achievement of Level 3 integrated working, there are limited actions related to contracts, appointments and insurance that could be taken in advance to facilitate early adoption of integrated working.

Full details of our recommendations, roadmap and examples of standard documents are included in Appendix 5.

5.3 Delivery Standards and Processes

The focus of this activity is to create demand pull from clients in a way that enables them to get clear answers to fundamental questions that need answering to progress through project gateways. We propose a range of contractual deliverables for the stages leading up to the letting of a contract for construction which are also sufficient to manage the transition between different design teams at different project stages. Where feasible these refer to national or international standards.

5.4 Education, Training & Support

Key to any successful change programme is communication of the change and adequate support during the process. We have worked with vocational and academic institutions and the various institutions to identify new ways to face the challenge and all are keen to engage in the process. The BIM topic and its earliest practical implementation and delivery requires accelerated adoption. This must be enabled by a general raising of competency through training and toolkits, supported by standards and accreditations for practitioners and Clients alike.

The recommended solution is a strongly led hybrid provider drawing on the educational and research expertise of universities, the robust experience of accrediting bodies and the engagement of credible industry led best practice, as well as vocational training delivered by CPD or the training supply chain.

The group believes this approach of engaging providers in the development and delivery of the material and standards will not only accelerate competency and adoption, but also will align the level and calibration of future industry professionals emerging from universities and provide a structure for lifelong development learning around BIM.

5.5 Improved Information Handover

In order to improve the measurement and management of public assets, it is recommended that public clients request that specific information be delivered by the supply chain. The specified information set, called COBie[1], delivers consistent and structured asset information useful to the owner-operator for post-occupancy decision-making. This 'information delivery' approach effectively insulates the public client from process complexity, technology change and competitive issues, which remain in the supply chain. A suitable system will be required to protect the integrity, security and process the information before use.

5.6 Information Use & Benefits

There is documented evidence both from the UK and overseas that all participants in the process of designing, constructing, owning and refurbishing buildings can gain substantial benefits in financial terms from the adoption of BIM principles. Stakeholder benefits have been closely reviewed and documented and we intend to develop recommended measurement processes to enable consistent recording of project performance and improvement as the strategy is delivered.

Appendix 11 & 17 describe how benefits are accrued by the Government client and indicates opportunities to gather further benefits already enjoyed by the supply chain.

5.7 Communications & Institutional Support

Consistent and cohesive communications and messages have been developed and delivered to Institutional Organisations, Trade Associations and Representative bodies who will be key in marshalling the industry response to the BIM challenge. The engagement process has revealed a significant consensus of support by these organisations for the introduction of BIM processes by Government procurers, as well as a commitment to future joint endeavour to support the further development of industry capacity and capability.

5.8 Investment

The task of developing this strategy has highlighted the difficulties in undertaking such a large task with a part time team. Whilst the technology steps we recommend are very small, the cultural, procedural and educational gaps are significant and with a programme of such enormous upside potential it is right that we take this opportunity to launch the UK Government response in an effective and significant manner. If this investment by the industry is going to be delivered in the timeframe of the current budget constraints and the five year strategic plan, a professional and effective management team are going to be needed to ensure delivery.

We have identified costs of circa £4M over the five year programme with some areas of potential income and match funding both from the industry and value adding activities that could be delivered by the support organisation.

5.9 Programme

A realistic programme for an industry change programme such as this is critical to sustain delivery over the five year period. We have set as a target of all suppliers of construction services to HMG to have reached the ability to deliver information and services of at least that of Level 2 in the maturity model described above.

There are five identified stages of the programme which are detailed in Appendix 16. The Working Group has been careful to maintain the progressive approach and has taken two very small steps at the beginning of the programme to commence progress.

[1] COBie (Construction Operations Building information exchange) was developed by a number of US public agencies to improve the handover process to building owner-operators.

The mobilisation phase will allow time for detailed planning and delivery of the support, communications, training and technology programme. Phase One will require the use of the new specified Contracts, guidance and deliverables. We anticipate working with identified early adopters in the Government Estate to demonstrate quick wins to provide early benefits and industry case studies.

6.0 Next Steps

The Working Group would like to invite the Board to:

1. Formally commit to the strategy and communicate this both internally and to the construction supply chain.

2. Convene a cross-government 'Implementation and Mobilisation' Task Group, to include representation for local and regional government to:
    a. Identify current capabilities
    b. To consider in details the information needs at key stages and ensure consistency of clarity to the supply chain.
    c. Suitable projects on which BIM practice can be demonstrated.
    d. To inform the client/industry group on mobilisation.

3. Invite the client/industry group to develop a funded mobilisation plan, to include:
    a. Creation, in conjunction with BSI, an appropriate deliverables framework
    b. Tailoring of the COBie methodology for Government requirements (to include carbon).
    c. Creation of appropriate metrics to monitor outcomes.
    d. Consideration of appropriate contractual clauses and requirements.

4. Act as the central body for 'stewardship' of the work and Communications strategy

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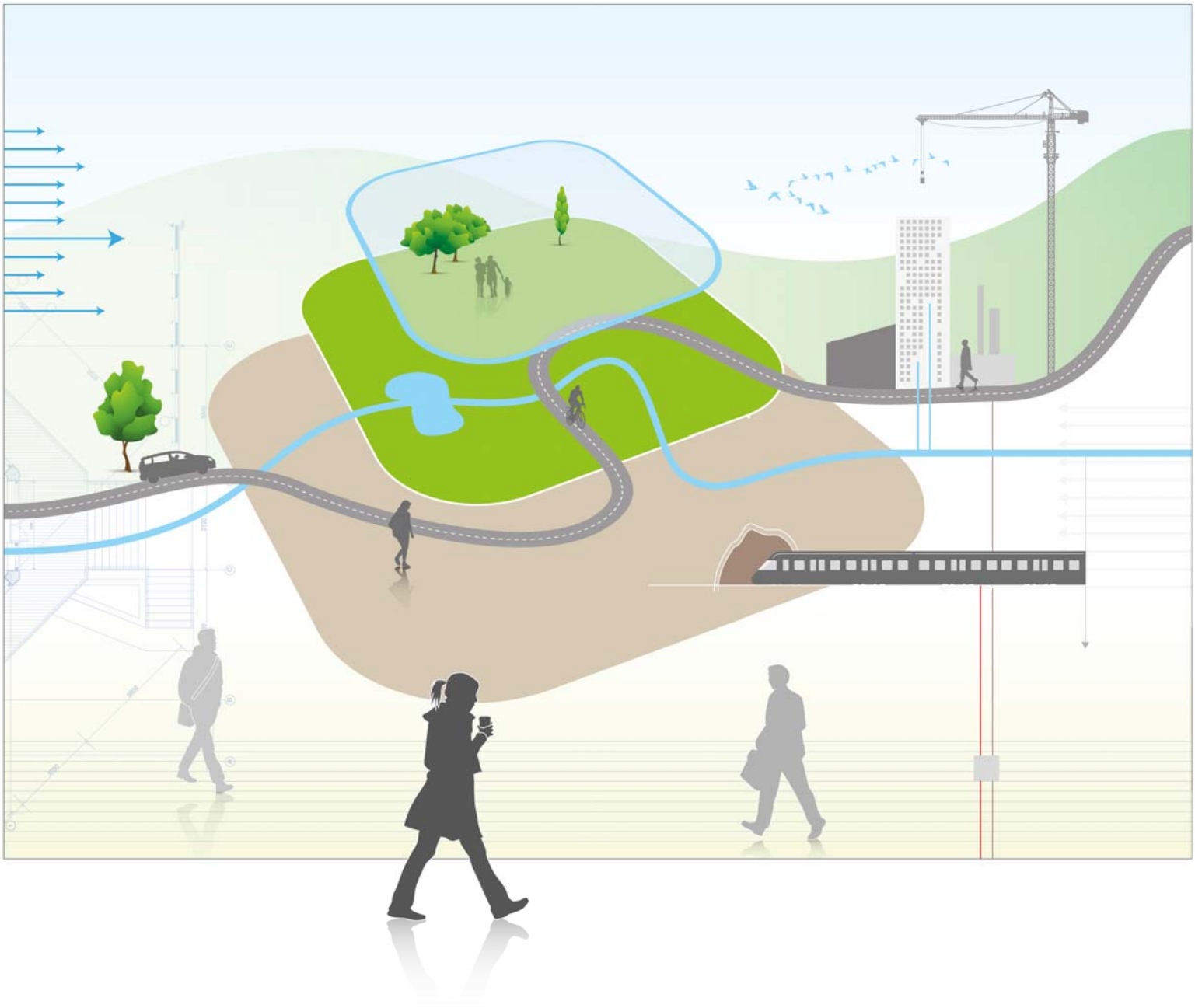

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Appendix 1

The Team

A vast number of individuals and organisations have been involved in the process of developing this strategy, many have been involved it the working groups. BIS would like to thank everyone for giving up their time and talent to this project.

The project has been co-chaired by John Lorimer of Manchester CC and Mark Bew of URS/Scott Wilson, supported on the leadership team by:

- Adam Matthews Autodesk
- Barry Blackwell BIS
- Michelle Barker BIS
- Nigel Fraser BAA
- Phil Jackson Bentley
- Prof Andrew Thomas Constructing Excellence
- Sanjeev Shah Unit 4
- Simon Rawlinson EC Harris
- Terry Boniface BIS

The following table summarises all inputs to work streams, review groups and those who have been consulted.

Name	Organisation	Work Stream Leader	Work Stream Group	Review Group	Consultation Group
Adam Matthews	Autodesk	☒			
Adrian Burgess	URS / Scott Wilson		☒		
Adrian Dobson	RIBA				☒
Alan Cripps	RICS				☒
Alan Redmond	University of Salford		☒		
Alan Yates	BRE			☒	
Anna Winstanley	Laing O'Rourke				☒
Andrew Bellerby	Tekla			☒	
Andrew Burke	NHF				☒
Andrew Croft	Beale & Company			☒	
Andrew Stanford	CIAT				☒
Andrew Wolstenholme	Balfour Beatty			☒	
Andy Ford	CIBSE				☒
Andy Green	F&G (Atkins)			☒	
Andy Stanton	TFL			☒	
Arto Kiviniemi	Salford University			☒	
Barry Blackwell	BIS		☒		
Bill Bowmar	Swift Horsman		☒		
Bill Price	Costain			☒	

Name	Organisation	Work Stream Leader	Work Stream Group	Review Group	Consultation Group
Bob White				☒	
Chris Gilmour	BAM		☒		
Chris Jones	Planning Portal				☒
Chris Kendal	Planning Portal				☒
Chris Penn	URS / Scott Wilson			☒	
Claire Bristow	CIC				☒
Daniel Theo	IBM		☒		
David Churcher	BSRIA				☒
David Frise	HVCA				☒
David Saffin	ZBP		☒		
David Taylor	URS / Scott Wilson			☒	
David Throssell	Skanska			☒	
Diba Salam	Aukett Fitzroy Robinson		☒		
Deke Smith	GSA - NIBS			☒	
Doug Bevan	Halcrow			☒	
Dr Sarah Graham	IES		☒		
Eddie Tuttle	CIOB				☒
Eric Winterkorn	RICS				☒
Frances Paterson	CIC				☒
Frank Moore	Autodesk		☒		
Gary Halbrook	BAM		☒		
Gary Saunders	Swift Horsman		☒		
Gary Watkins	BIFM				☒
George Aucamp	Faithful + Gould USA		☒		
Gordon Masterton	CIC				☒
Graham Watts	CIC				☒
Helen Woolston	TFL		☒		
Iain Brixey	Skanska				☒
Ian Davis	Birmingham City Council		☒		
Jack Fraser	SWG				☒
Jack Pringle	CIC				☒
James Brayshaw	Ordanace Survey		☒		
James Brown	Asda			☒	
James Hall	Associated Architects		☒		
James Roundtree	Halcrow		☒		
Jamie Johnston	Brydon Wood		☒		
Janet Wilson	IUK		☒		
Jason Underwood	University of Salford		☒		

Name	Organisation	Work Stream Leader	Work Stream Group	Review Group	Consultation Group
Jeff Stephens	Vinci Construction		☒		
Jennifer Whyte	Reading University		☒		
Jillian Hastings	CLG		☒		
John Ioannou	OGC				☒
John Lorimer	Manchester CC (Joint Chair)	☒			
John Roycroft	BDP			☒	
John Tocci	Tocci Building Companies				☒
Jon De Souza	Constructing Excellence				☒
Jon Wallsgrove	Architect MOJ			☒	
Kamila Tomaszewska	CIC				☒
Kate Young	Halcrow		☒		
Keith Snook	RIBA				☒
Lisa Gould	Wates			☒	
Mark Bew	URS/Scott Wilson (Joint Chair)	☒			
Mark Langdon	APM				☒
Mark Way	CIC				☒
Martin Davis	Synopsis		☒		
Martin Howe	Bevan Brittan		☒		
Matthew Hutchinson	St Gobain		☒		
Mervyn Richards	MR1 Consulting			☒	
Michael Brown	CIOB				☒
Michael Edwards	BSF			☒	
Mike Clarke	URS / Scott Wilson			☒	
Mike Underhay	Arup			☒	
Michelle Barker	BIS	☒			
Nick Nisbet	AEC3 Consultant		☒		
Nigel Fraser	BAA	☒			
Nigel Stroud	BAA			☒	
Nigel Tilley	Microsoft		☒		
Norman Train	IstructE				☒
Paul Meigh	OGC			☒	
Paul Morrell	BIS				☒
Paul Shillcock	TFL			☒	
Peter Capelhorn	CIC				☒
Peter Cochrane	Birmingham City University		☒		
Peter Moyes	Artra		☒		
Peter Rebbeck	BSI			☒	

Name	Organisation	Work Stream Leader	Work Stream Group	Review Group	Consultation Group
Phil Jackson	Bentley		☒		
Phillip Brown	Swift Horsman		☒		
Prof Andrew Thomas	CE	☒			
Prof Matthew Bacon	Eleven LLC		☒		
Prof Tim Broyd	Halcrow			☒	
Rennie Chadwick	Vinci Construction			☒	
Richard Ogden	Build Offsite				☒
Richard Saxon	CIC				☒
Rob Charlton	Space Architects			☒	
Rob Manning	CIBSE				☒
Rod Mcdonald	Buro Happold				☒
Sanjeev Shah	Unit 4		☒		☒
Sara Fray	IstructE				☒
Scott Steedman	BRE			☒	
Simon Godfrey	SAP		☒		
Simon Lawes	ABE				☒
Simon Raine	Faithful & Gould		☒		
Simon Rawlinson	E C Harris	☒			
Stephen Bamforth	Griffiths Armour		☒		
Stephen Jones	TFL		☒		
Stephen Matthews	CIBSE				☒
Steve Brunning	Rapid 5D Ltd		☒		
Steve Dunwell	Oracle		☒		
Steve Jolley	Bentley		☒		
Steve Lailey	ICES				☒
Tammy Adams	CLG		☒		
Terry Boniface	BIS	☒			
Tom Taylor	APM				☒
Tony Bassett	Gifford			☒	
Tony Broomhead	Arup			☒	

Appendix 2

The Hypothesis

The working group devised a hypothesis and a number of 'tests' to guide and validate its work and to develop a strategy for the phased widespread introduction of BIM with increasing maturity (Appendix 3). This was designed with the express desire not to attempt to try and define what BIM is, rather than focus on the outputs of BIM.

"Government as a client can derive significant improvements in cost, value and carbon performance through the use of open sharable asset information"

To ensure that the hypothesis can be robustly tested we identified the following tests.

- **Valuable:** The overall aim is to maximise client value by increasing benefits at little or no extra cost.
- **Understandable:** The approach is to be presented in an understandable learning package suitable for different types of government asset procurers.
- **General:** The approach is equally applicable to buildings and infrastructure, whether large and small new build and where possible existing structures.
- **Non Proprietary:** All requirements are non-proprietary as to applications and as to the required formats of the deliverables.
- **Competitive:** Wherever possible there are at least two solutions or methods available so as to minimise market influence in terms of anti competitive clauses.
- **Open:** Wherever possible, low-cost methods are to be made available to allow all stakeholders to participate, irrespective of size and experience, so as to minimise barriers to involvement.
- **Verifiable:** All contractual expectations are documented with transparent and testable measurement of pass / fail.
- **Compliant:** Measurement of WLC/Carbon/Sustainability/etc is published to GB, EU and ISO standards.
- **Implementation:** The approach is self funding by the client and the industry.
- **Timescale:** The approach is phased in over 5 years.

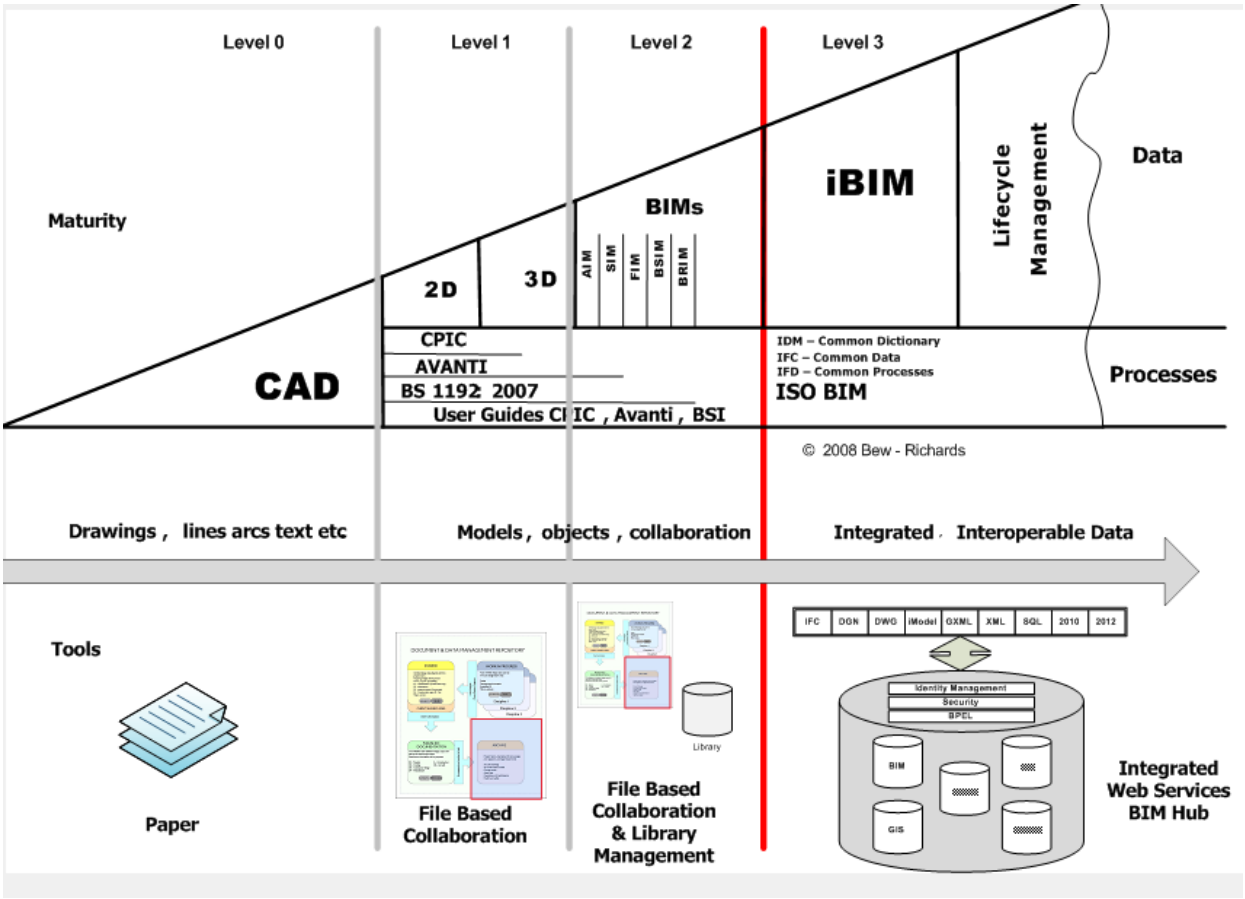
Appendix 3

BIM Maturity Levels

A maturity model has been devised to ensure clear articulation of the levels of competence expected and the supporting standards and guidance notes (not shown in this diagram), their relationship to each other and how they can be applied to projects and contracts in industry.

The purpose of defining the Levels from 0 to 3 is to categorise types of technical and collaborative working to enable a concise description and understanding of the processes, tools and techniques to be used. In essence, it is an attempt to take the ambiguity out of the term 'BIM' make specifying for it clear and transparent to the supply-chain and enable the client to understand precisely what is offered by the supply-chain.

The production of this maturity index recognises that differing construction client and their supply organisations are currently at different level of experience with their approaches to BIM and serves as a structured 'learning' progression over a period of time.



Level Definitions

0. Unmanaged CAD probably 2D, with paper (or electronic paper) as the most likely data exchange mechanism.
1. Managed CAD in 2 or 3D format using BS1192:2007 with a collaboration tool providing a common data environment, possibly some standard data structures and formats. Commercial data managed by standalone finance and cost management packages with no integration.
2. Managed 3D environment held in separate discipline "BIM" tools with attached data. Commercial data managed by an ERP. Integration on the basis of proprietary interfaces or

bespoke middleware could be regarded as “pBIM” (proprietary). The approach may utilise 4D programme data and 5D cost elements as well as feed operational systems.

3. Fully open process and data integration enabled by “web services” compliant with the emerging IFC / IFD standards, managed by a collaborative model server. Could be regarded as iBIM or integrated BIM potentially employing concurrent engineering processes.

Appendix 4

International Alliances

BIM should be considered in the context of the increasing Globalisation of the construction supply-chain and more homogenisation and greater consistency of basic construction-client information requirements - which are now increasingly driven by national regulation on energy performance and 'carbon' accounting.

There are a number of national deployments of BIM currently in progress across USA, Scandinavia/Europe and the Far East which are at varying levels of maturity. Increasingly, these states recognise that the pace of construction globalisation is accelerating owing to a number of factors, but not least owing to the increasing deployment of digital technology and communication / geospatial technology.

Greater global cohesiveness in relation to BIM presents both opportunity and risk. The working group considers that the principle risk to the UK - other that the risk associated with a failure to have a strategic approach to BIM which this document seeks to address - is the unnecessary and avoidable divergence in the strategic direction of BIM to the norm encountered on the international stage. BIM software and technology is marketed on a global basis in almost identical forms and whilst such software has inherent flexibility the market will decide its development. Should the UK diverge against the prevailing market, it will not necessarily mean that the UK is entering into 'blind' technology or knowledge alley, but it would be constitute a circuitous and more difficult route in maintaining BIM knowledge and competitiveness both of which are increasing important in facilitating national growth (as a central element of UK Government Policy).

The working group recognises that at this early stage in the international maturity of BIM there is an opportunity for significant synergies in combined international effort in developing BIM policy, implementation and mobilisation strategies. The working group considers that there is a real opportunity for the UK to take a leading role in shaping the future international development of BIM by UK Government Construction Client Board adopting strategic-level collaboration approaches with their peers from other national Governments.

The working group recommends that the Government Construction Client Board forms a strategic level alliance with the US Federal Facilities Council, the US National Institute of Building Science (including GSA) and their equivalencies in Scandinavia and Europe. Significant work has already been undertaken with our US colleagues in the preparation of this strategy and a draft alliance agreement is copied in this Appendix below.

A DRAFT Strategy for Holistic Facility Sustainability in the United States and United Kingdom

Goal: To coordinate research, development, education, implementation, and deployment of information age strategies for the facilities industry.

Background: Historically the facilities industry has been extremely fragmented. The conversion of this ancient industry to the information age is fraught with many challenges from cultural to technological.

Discussion: A Building Information Model (BIM) should be the central hub for all information about the facility from its inception onward. This information takes on many shapes and has many roles to play. Accurate geometric and intelligence about the planning, design, construction, and operation of a facility is needed by current and future tools for analysis and reporting. Information must interoperable be able to support all the opportunities shown below:

Simulation
Building Green
Carbon Footprint
Lean Construction
Integrated Project Delivery
Deconstruction

High Performance Buildings
Virtual Design and Construction
Real Property Asset
Management
Analysis
Resiliency
Raw Material Consumption

Sustainability
Value Engineering
Life Cycle Costing
Energy Conservation
Preventative Maintenance
Environmental Stewardship

Proposal: It is proposed that the National Institute of Building Sciences in the United States and the Government Construction Client Group in the United Kingdom should identify areas of potential non-exclusive collaborations which would be mutually beneficial in the implementation of BIM across the design, construction and operations of built assets. A central ambition of the collaboration would be the sharing of information derived for project or policy. In particular, it is viewed that collaboration would mitigate the possibility of unnecessary complication and fragmentation (with consequences of increased cost and reduced innovation) in national technological/procedural application of BIM. The collaboration would also seek to derive synergies in joint development of policy and protocols and in that way minimize the duplication of effort and allow for leverage of scarce human and financial resources

In the first instance it is recommended that a 'virtual' working group composed of representatives of each nation be established to explore and assess areas where potential beneficial areas exist and recommend to both NIBS and GCCB how they should be taken forward.

The National Institute of Building Sciences was established in 1974 by an act of Congress to build bridges between various sectors of the facilities industry both private and public. Since 1977, the Institute has been a non-profit organization relying on private and public sector funding of projects such as these to provide its funding.

The UK Government Construction Client Group …
Prepared by Dana K. Smith, FAIA and National Institute of Building Sciences

Appendix 5

Legal, Contracts & Insurance

1. Overview and outline of work streams

The objective of the Legal, Contracts and Insurance work stream is to provide a comprehensive overview of the push/pull issues which need to be addressed to encourage the accelerated adoption of BIM on Government Construction Contracts. Contractual and commercial issues have the potential to act as a source of inertia holding back adoption on projects. The development of a limited range of standard support documents will support pull by the government client and will facilitate a more effective response from the supply chain.

The key activities of the work stream are:

a. Copyright and IP – a review of legal principle as it applies to information held in BIM environments
b. Ownership and sharing of data – a practical review of the steps that need to be taken to facilitate effective BIM working
c. Insurance and liability – a review of the influence of insurance-related matters on information sharing in a BIM environment
d. Integration with existing contracts and appointment documentation – including details of the supporting protocols
e. Commercial issues – a review of wider commercial considerations including procurement practice, approvals and payment for work in progress
f. Maturity model – a prioritised road map for the development of commercial and contractual capabilities

2. Key recommendations for legal, contracts and insurance

a. IP will not be a barrier to BIM adoption. The Government Construction Client should provide a clear consistent message to industry with respect to requirements re transfer of copyright. Agreements should only provide rights that are immediately beneficial to the client during the asset lifetime
b. IP associated with collaborative working is in development. The Government Construction Client should actively contribute to the definition of state of the art of IP vested in shared BIM models, collaborative working environments and virtual teams
c. Procurement. Pre-qualify supply chain on BIM competence and capability. Procure on basis of level of integration required. Focus later stages of team selection on design quality and management capability, rather than technical issues related to BIM ability
d. Contracts. Draft simple standard contract amendments requiring compliance with BIM protocols
e. Consistent requirements. Develop standard BIM Protocols clearly setting out requirements for project delivery and outputs such as FM. Work with industry to agree a standard Protocol early in the 5 year programme
f. Define new duties for consultants and contractors working in the BIM environment – particularly the model manager and reciprocal duties of other participants
g. Demand wider adoption of BIM-driven ways of working. Clients should expect all consultants including QS's and Project Managers to be familiar with BIM and to be actively developing ways in which processes can be made more cost effective and value-adding
h. Clarify risk transfer as model passes from consultant to contractor to client – consider aspects of integrated team working at Level 2

i. Consider insurance products to support effective working in the BIM environment. Draft standard clauses for insurance for NEC to encourage consistent adoption
j. Undertake detailed actions ahead of the maturity model to accelerate achievement of Level 2 Working.

3. Findings in the context of the main recommendations of the report

Leave complexity and competition in the supply chain

a. Existing contracts can be used with minimal amendment – enabling clients to set out their requirements in output terms – leaving the supply chain to develop and deliver solutions via a pull model
b. Details of requirements should be described in the BIM protocol and schedule of services – not the form of contract. These requirements should be standardised (where this makes sense) at an early stage during the 5 year programme so that innovation is responding to a consistent requirement – rather than conflicting standards
c. Ownership and coordination of the model should remain within the supply chain during the currency of the design and construction contracts.

Be very specific with supply chain providers, they will only provide that which is asked for.

a. Where client standards are defined – integration with a wider programme model or FM systems for example – these can be incorporated into the BIM protocol
b. Further infrastructure will need to be developed to set out these requirements. Examples include schedules of service outlining additional responsibilities related to BIM, expected outputs similar to the BSRIA design framework and information exchange, quality standards such as BS1192:2007 or drafting standards such as the AEC UK BIM Standard
c. The Construction Industry has a good track record of producing standards collaboratively but there a number of independent groups. Government action to promote a single set of standards will accelerate adoption.

Make active use of outputs

a. Contracts and protocols can set out any requirement, but it is up to the construction client to pull adoption through the active use of BIM outputs. Contracts and protocols should accordingly be tailored to the level of BIM integration expected from the project.

Provide support infrastructure for Push & Pull

a. The definition of the role and responsibility of the model owner/model manager is a key push initiative - clarifying activities, outputs and the extent of design responsibility associated with a shared model
b. Project insurance also needs to be considered with regard to its role in shaping participant behaviour on projects – our recommendation is that Government Construction clients should promote the development of Integrated Project Insurance ahead of level 3 BIM integration, and that standard insurance clauses for NEC should also be developed
c. The amendments proposed to Legal Contracts will not push adoption of BIM, but will reduce inertia. Appropriately drafted schedules of service, BIM protocols, together with wider adoption of existing standards will provide a support infrastructure to both pull and push by enabling the Construction Client to clearly and consistently define requirements whilst allowing the supply chain to organise itself around well-defined roles
d. Standard protocols and service schedules should be developed to promote a consistent pull across the industry.

Take progressive steps

a. The use of a BIM protocol outside of the contract means that a graduated approach to increasing the extent of BIM utilisation can be adopted without the need to redraft contracts. Our recommendation is that progressive steps taken by the industry should be encouraged by Government construction clients' adoption of a phased sequence of protocols and standards.

Have a clear target for the "Trailing Edge" of the industry

a. BIM-compatible amendments to contracts can be incorporated into any form of contract. BIM protocols will provide appropriate flexibility for the training edge to be accommodated.

Workgroup Findings

Copyright and IP

Workgroup Membership

The working group was chaired by John Henderson of Beale and Company, with input from Andrew Croft (Beale and Company), James Rowntree (Halcrow), Matthew Hutchinson (St Gobain), Chris Gilmour (BAM) and Gary Saunders (Swift Horsman).

Recommendations

a. Summary of IP legislation in England and Wales
   - Under Section 1(1)(a) of the Copyright, Designs and Patents Act 1988 ('CDPA') copyright subsists in original literary and artistic works, including every production in the literary, scientific and artistic domain, which includes works of architecture, plans, sketches and three-dimensional works relative to architecture or science
   - Work needs to have originated from the author and must be 'substantial' – sufficient work and skill must have been expended in its production
   - Copyright will be infringed if a three dimensional copy of the building is produced, whether as a model created from two dimensional drawings or by constructing another building. A graphic work or photograph does not infringe copyright
   - The majority of documents (whether electronic or paper) produced in the construction of a building will be protected as artistic works, under which sketches, plans and elevations are protected, irrespective of their artistic quality
   - Ownership of copyright generally resides with the author, not the individual who commissions it. Copyright typically vests in the employer rather than the individual producing the work
   - Copyright does not have to be registered
   - Copyright in the design of a building (as distinct from any particular element of that building, such as its structural frame) resides with individual or individuals who were the effective cause of the shape and design of the building, i.e., the consultant design team rather than the contractor team.
   - Copyright in computer generated works. Where work is produced with the aid of software and it is impossible to identify the human author of the work, the author for copyright purposes is deemed to be the person who made the arrangements necessary for the creation of the work. This normally means that the company which owns or directs the use of the IT systems concerned is the owner. This provision only applies where the computer creates the model with very little human input and it is not possible to identify the human author. In a BIM environment for example, if the model manager uses sufficient skill in adapting the software to the project and collating the individual models, he might be the owner of copyright in the *model.*
   - Database right. The database right is distinct from copyright and applies without prejudice to rights existing in respect of the contents of the database. The ownership of the database right lies with the individual who takes the initiative and assumes the risk of investing resources in the obtaining, verification or presentation of the database, the benefits of which would be lost if the right is infringed. A BIM model might fall within the definition of database, although this was not the original purpose of the provision. In practice, ownership of any database right may depend on the arrangement between the parties, as, aside from any agreement, if the model manager invests significantly in the model and bears a significant risk regarding its contents they could hold the database right.

- Design rights. Broadly speaking, the purpose of design rights is to protect the design of purely functional things, such as tools and ownership belongs to the commissioner. There is no copyright protection for making an article to the relevant design document.

How copyright works can be used by others

- Copyright gives the owner the exclusive right to authorise or prohibit the exploitation of the copyright work by third parties, which includes the right to copy the work itself and to use the work in certain protected ways, such as issuing copies to the public and making an adaptation of the work. If these acts are undertaken in relation to the whole or a substantial part of the work, without the agreement of the copyright owner, the owner can take legal action against the third party. Whether the exploitation is in relation to a substantial part of the work depends on the quality of the copy rather than the quantity. Copyright may be infringed if a drawing is used in the construction of a building even though the end product does not mirror the original drawing.
- Rights over copyright work can be granted via a licence whereby ownership remains unchanged, but rights are granted to the licensee.
- Copyright can also be assigned which transfers the ownership of copyright and may allow the assignee to use the copyright work as if they were the owner from the outset.
- A licence can be implied, for example where a drawing is produced in return for remuneration for use in relation to a project. An express license usual contains a term controlling how the work subject to copyright can be used – typically limiting use to construction, use and sale of the building.
- The current typical wording of licences could be redrafted to permit wider use of material held in a BIM environment (for adaptation or refurbishment for example) albeit issues of liability and compensation need to be considered and are outside of the scope of this paper.

Issues arising from the application of IP law to BIM projects

- Protection of IP rights on a conventional project. The existing arrangement where the owner of copyright retains ownership, but gives a licence to its Employer to use the copyright work for the purposes of the project could be adopted on a BIM project subject to the following considerations:
  - Use, supervision, termination and assignment of the licence. Uses permitted by the licence will need to be extended as a greater level of BIM integration takes place
  - Subsequent use by a party of work/know how developed on an earlier project. Restriction of the extent to which copyright work can be used post-completion to clearly needs to be addressed but the government construction client can support this by being pragmatic with regards to the extent of the scope of reuse and issues of liability
- Copyright of the whole model. It is unclear where ownership will reside in a maturity Level 3 BIM model. For example, if the model manager uses sufficient skill in adapting the software to the project an collating the individual models, he might be the owner of copyright in the model. Ownership of copyright in the model will not impact on the ownership of copyright in the individual contributions. The Employer will need to ensure that it obtains an adequate licence or assignment of the copyright in the model.

Issues arising from increasing collaborative working

- Joint authorship. Work produced by the collaboration of two or more authors in which the contribution of each author is indistinct from that of the other authors will be deemed to have joint authorship. Joint ownership is unlikely to be an issue on a Level 2 BIM project, as if work is created by one party and amended by another, it is likely that both parties will own copyright in their distinct contribution to that work. Issues are more likely to arise on a Level 3 BIM project, if true collaboration in the design takes place.
- Practically, the fact that work is jointly authored may not be an issue as it would simply mean that in order for the Employer to make use of jointly authored work licences must be granted by all authors. Provided the Employer has obtained licences from all consultants/contractors involved in the design process, this will not be a practical issue. However, joint authorship potentially affects the reuse of material by one or more of the authors, as permission is required from all parties. To simplify matters and to ensure that joint ownership issues do not arise, the parties could agree to assign any joint ownership that arises as a result of contributions back to one owner.
- An alternative approach which will provide a clear audit trail demonstrating the development of the model is that adopted in the AIA's BIM Protocol Exhibit (Document E202 -2008), whereby responsibility for each aspect of the model is allocated to a specific party in a Model Element Table and it is therefore clear who owns the copyright in each element. This approach does however reduce collaboration by restricting work of participants to defined elements.
- Implications of amendments. Generally, where work is amended by a party other than the creator, it will mean that both parties own copyright in their respective contributions to that work. An amendment to a model by one party to a part of the model prepared by another could attract its own copyright if the amendment is substantial. The AIA approach described above removes this risk by requiring parties to adhere strictly to their disciplines and elements and as long as there is a clear audit trail demonstrating who has done what, there is unlikely to be any issues.
- Record copies. Licences should be drafted in such a way so as to ensure that parties have sufficient licences to view and store the model.

Analysis of current practice in the United States

- Two addendums to be used on BIM based projects have been developed in the US:
  - The AIA E202 – 2008 BIM Protocol Exhibit
  - The ConsensusDOCS 301 BIM Addendum
- Ownership definitions. Both documents state that contributions to the BIM model do not deprive the contributor of ownership to its copyright.
- Licences. Both the AIA and ConsensusDOCS protocols restrict use of the model to purposes related to the design and construction of the Project. The ConsensusDOCS Addendum contains a much more detailed licence than the AIA protocol, which grants rights to the Owner/Employer/Contractor in relation to:
  - The consultant's contributions
  - The contributions of other Project Participants who have granted the consultant a sub-licence
  - Any model incorporating Contributions.
- The Consensus DOCS Addendum also confers additional rights to parties to grant licences to any other party with which the Contributing Party has a contract to which the Addendum is attached. This could potentially override the provisions of the licence or assignment between the two parties in that the licence will no longer be exclusive. As a result of these provisions, providing that all parties to the project have the Addendum attached to their contract, no IP issues will arise should a party review or use another party's documents.
- Use of contributions. The ConcensusDOCS Addendum limits the extent to which the Contributions can be used post completion by stating that after completion of the project the licence shall be restricted to keeping archival copies of project related contributions. Subject to the terms of the Architect/Engineer's licence, the Owner could potentially be entitled to use the BIM for O & M purposes, but not the individual contributions.
- The licence in the Addendum is revocable in the event of a court of law or arbitration decides that the project owner has failed materially in its payment obligations.

Practical issues associated with the ownership and sharing of data

Working Group Membership

The working group was chaired by Chris Gilmour of BAM, with input from Nigel Fraser (BAA), David Saffin (ZBP), Diba Salam (Aukett Fitzroy Robinson), Matthew Hutchinson (St Gobain), Philip Brown (Swift Horsman), Rob Charlton (Space Architects).

Recommended Actions

- Lead-consultant to be appointed with single-point responsibility for design – employing sub-consultants directly.
- Consultant, contractor and supply chain pre-qualification should include BIM competence and readiness, including access to technology and communications infrastructure.
- Appointments and protocols to define ownership of the model and responsibilities of each team member.
- Standard BIM protocols to be agreed at institutional, sector and project level.
- Specific appointment for model management including demonstrable virtual management competences.
- Phased adoption of BIM recommended so that supply chain can develop capability.

Best practice BIM ownership and data sharing

- Preference for use of collaborative forms of contract such as NEC, with a collaborative scope of services such as the CIC
- Pre-selection of teams should take account of commitment to and capacity to implement BIM.
- Appointments which facilitate collaborative working should be encouraged – e.g. lead consultant appointed directly by the client with other consultants appointed as sub consultants by the lead consultant.
- Standard BIM protocols must be set up at the beginning of each project, detailing:
  - Responsibilities of all members of the team
  - Use of common software, modelling standards and exchange standards
  - Clear definition of what is “handed over” to the client at the completion of the project
  - The BIM Protocol will be referred to in contracts and appointment documentation.
- A BIM Co-ordinator must be identified, but this is not necessarily an independent appointment – (e.g. model manager/virtual design and construction manager).
- Note importance of readily available technology and access to models for all participants – note pre-qualification issues of hardware capability and broadband speed.
- Construction client should expect the project team to “Build the project twice” (once in a computer and once on site).
- Construction client should expect the input of specialist manufacturers producing component parts in 3D CAD with data attached for including in the model.

Basic requirements for effective BIM implementation

- Clarity as to the extent of integration required – e.g. use BIM protocol to put foundations in place from the start – particularly if BIM data is going to be used directly to support FM etc.
- Clear BIM protocol describing deliverables, deliverables programme, purpose of deliverables and formats.

- Consistent use of compatible BIM packages – or effective translation/integration software.
- Recognition of cultural and business changes required – and how these might be supported by the client.

Potential barriers related to data ownership and information sharing

- Additional resource required by data originators (e.g. Architects) to facilitate reuse – up to 15% additional resource.
- Clarity re management of the transfer of ownership of and responsibility for the model during the lifetime of the project (e.g. designer to contractor to owner). This can be described in the Protocol but transfer of responsibility/risk also needs to be clear.
- Capability of project participants (e.g. ability to invest in software, hardware and training, competence of team, willingness to adopt client's protocol).
- Conventional contracts and commercial arrangements acting as a potential barrier to the implementation of collaborative working with BIM.
- Industry fragmentation (e.g. complex supply chains and multiple professional institutions) is a barrier to ready implementation.

Commercial and legal issues related to data ownership and information sharing

NOTE: the working group has commented on these issues at the highest level only

- The perception of the working group is that copyright and IP issues are not significant enough to act as a barrier to BIM adoption – simple solutions should be developed.
- Design responsibility need to be clearly allocated and delineated – particularly in early stages of integrated working. Options available include:
  - Appointment of the lead consultant with overall design responsibility
  - Appointment of separate model manager with sole responsibility for the building and coordination of the model.
- Contracts which support collaborative ways of working are likely to facilitate BIM exploitation.
- Mechanisms need to be in place to allow commercially sensitive information to be held independently of the shared model – e.g. a contractor's bid data.

Integration with existing contract families

Working Group

The working group was chaired by Martin Howe of Bevin Brittan, with input from Simon Raine (Faithful and Gould) and Philip Brown (Swift Horsman)

Recommended actions

- The group recommends that contractual requirements for BIM are incorporated through a BIM protocol. Protocols need to be drafted to support different levels of integration as part of the evolutionary model
- Protocols will be incorporated by reference into any of the standard form contracts or professional appointment documents on the basis of a simple additional clause.
- Dispute resolution provisions will remain unchanged, but the practicalities of identifying contributions may become progressively more complex. In principle, there is no reason for why responsibilities should be very different from existing 2D design, providing the extent of each designer's responsibilities are clearly spelt out and understood. We recommend that duties are reviewed so that the cascade of responsibilities is made clear. Adoption of Integrated Project Insurance at higher levels of integration will reduce the reliance on these dispute resolution mechanisms.
- Additional duties will need to be defined in schedules of services for professional appointments describing additional services and outputs that might result from the BIM based project. The duties required will vary in accordance with the degree of integration required. Schedules of service and BIM Protocols need to be drafted consistently

Overview

- The group has considered the implementation of BIM in the context of the NEC, JCT and ICE contract families. None of these contracts deals in any way with the use of BIM - nothing mandates or prevents the use of BIM at any stage.
- Similarly none of the existing standard form professional appointments prepared by the respective professional bodies and/or organisations such as the British Property Federation and the Construction Industry Council refer to the use of BIM.
- The group has not considered issues associated with the use of BIM in connection with FM and maintenance contracts.
- The group has not considered issues associated with the adoption of an existing BIM model as the basis for the refurbishment or adaptation of an asset originally produced using BIM information.

Design appointments

- Additional duties will need to be defined in schedules of services for professional appointments describing additional services and outputs that might result from the BIM based project. The duties will vary in accordance with the degree of integration targeted, but could be standardised.
- Duties also must be defined for the role of 'model owner/manager' – (e.g. BIM Co-coordinator/virtual design and construction manager). These will be a standalone set of duties associated with the role of model manager. An outline of the potential duties is set out as an exhibit to Appendix 5 – based the format of the CIC schedule of services.
- Duties for the lead consultant - covering specific responsibilities around directing the production of models and model outputs in accordance with agreed standards etc., also need to be drafted.

- Duties for design consultants - based on the ConcensusDOCS approach, limited additional duties will be required. As integration increases greater clarification around origination, review, coordination and integration will be necessary to clarify design responsibility.

Construction contracts

- Incorporation of BIM provisions. Protocols will be incorporated by reference into any of the standard form contracts or professional appointment documents on the basis of a simple additional clause, along the lines of "the Contractor shall work with [its] [the Employer's] [design consultants] [Contractor] in accordance with the attached BIM Protocol".
- The advantage of the approach is that standard BIM protocols can be adopted across a range of contract families without extensive drafting to suit the wording of the main contract.
- The BIM protocol would be issued as a contract document – e.g. as Works Information under NEC3.

Insurance and liability

Working Group

The working group was chaired by David Saffin of Zisman Bowyer and Partners, with input from Gary Holbrook (BAM), James Rowntree (Halcrow), Philip Brown (Swift Horsman), Martin Davis (Synopsis) and Stephen Bamforth (Griffiths and Armour)

Recommended Actions

- The group considers that collaborative working methods will support the optimum development of BIM for design, construction and operating information. It is anticipated that this form of collaborative working will be supported by existing contracts such as NEC.
- In line with the BIM maturity model the group acknowledges that a partial 'step through' approach would align effectively with existing contractual and insurance practice.
- Insurance products will need to be developed to respond to the increasing integration of design, construction and operation information – in advance of the adoption of working methods based on fully Integrated Project Teams. These products need to be developed.
- Integrated Project Insurance products have been developed but need to be tested on a wider range of pilot projects – they have significant potential to serve as a liberating environment for the development of BIM.
- The NEC family of contracts provides total flexibility with regards to defining a project's insurance provisions. The group recommends that standard clauses for Integrated Project Insurance are drafted and adopted by Government Construction Clients as a standard as part of the adoption route-map.

Suitability of current insurance models

- The-group's view is that existing insurance provisions are adequate for the style of collaboration envisaged at level 2 BIM, on the assumption that the extent of integration would involve a number of models being brought together in a coordination exercise with audit trails similar to that found at level 1.
- The group's view is that there is a willingness within the Insurance industry to adapt quickly to changing contractual relationships, in step with increasing levels of collaboration.
- The group's view is that current Insurance provisions for design or construction reflect the adversarial nature of the contractual relationships between the parties and the need to manage risk. This framework of separate insurances is costly and contributes further to the relatively high cost of construction in the UK.
- These arrangements support a blame/liability culture, which in turn results in a 'silo' mentality with each party effectively protecting itself from the other. These behaviours are counter to and have a negative impact upon collaborative working.
- The full benefits of collaborative working are more likely to be realised within a 'team' environment with members committed to a set of common objectives – without the influences of third parties such as insurers.

Suitability of integrated insurance models

- The group's view is that Level 3 integrated BIM will bring greater opportunity for the formation of 'Integrated Project Teams'.
- Details of the operation of integrated project teams are described in the Strategic Forum toolkit.
- The IPI policy has been developed by members of the construction and insurance industries. The policy is inclusive of independent risk assurance and latent defects cover. It replaces all traditional all risks, public and product liability and professional indemnity policies throughout the supply chain. Overspend of the agreed cost plan is also covered. Rights of subrogation are waived against the risks covered under traditional policies.
- Integrated Insurance Policies are backed up by an independent technical and financial appraisal/assurance of proposed design solution and cost plan. Independent appraisals are the culmination of inter-active consultations undertaken by the independent technical and financial risk assurers. The resulting joint report will be used as the basis of the approval of the design solution and cost plan for cover by a single IPI policy.

Other commercial issues

Working Group

The working group was chaired by Simon Raine of Faithful and Gould
John Lorimer (MCC), Philip Brown (Swift Horsman), Martin Howe (Bevan Brittan), Rob Charlton (Space Group), George Aucamp (Faithful + Gould USA), James Hall (Associated Architects), Peter Cochrane (Birmingham City University)

Overview

This section of the report provides a brief commentary on wider commercial issues. No recommendations for action are made at this stage.

Integration of Cost Management and Programme outputs into the BIM model.

- Much BIM software is capable of producing 'schedules of quantities' and enabling the construction sequence to be simulated prior to construction. This capability would suggest that Cost Management and Programming activities can be readily brought into the BIM environment – particularly at earlier stages of design development. However, the effective adoption of BIM technologies by cost consultants and planners has been slow to date, and should this situation remain, then cost and programme services will not benefit from the productivity and speed of response that a settled BIM process can offer. This is not to say that the adoption of BIM will not be without its challenges, but that the professions cannot afford to be outside of the BIM loop.
- Approaches to cost estimating using BIM software.
    a. Stand-alone model. Contractors and a small number of consultants have adopted the practice of creating stand-alone BIM models specifically for pricing. Whilst this involves some duplication of work, the model can be developed to utilise standard 'pricing objects' and can be designed to output cost and quantity information in pre-defined formats. This is currently the most effective way of producing contractors' quantities using a BIM. Another advantage of this approach is that sensitive commercial data can be kept confidential. The main challenge associated with the stand-alone model is the need for operatives with specialist skills, together with the need to coordinate the model with the work of the project team;
    b. Direct interrogation of a model. This approach involves using the scheduling capabilities of BIM software – typically downloading schedules of quantities into Excel for further sortation. The outputs have a 1:1 relationship with the objects in the model, so it is essential that the BIM model is produced with the intention of deriving appropriately sorted quantities. Direct interrogation is the simplest approach and works well on smaller projects. The advantage of the approach is that information is only produced once. However there are challenges around the interrogation of information from discipline-specific BIMs together with linking to rates libraries or estimating software.
    c. Indirect interrogation of a model. Under this approach, a query tool is used which creates links between the BIM and a proprietary estimating system. This hybrid approach enables suitable BIM data to be used alongside more conventional measurements. Some systems have the facility to link a BIM model with a cost plan, enabling the measurement of updated models to be automated. The advantage of the approach is that specialists continue to use their preferred tools, supported by a high level of automation. The challenge relates to the quality of the information in the BIM relative to a design stage.

- Each approach is valid and applicable for different users of cost data in the supply chain. Approaches a) and c) have greatest promise for contractors and cost consultants respectively.
- Effective utilisation of BIM for estimating, particularly at early stages, will be dependent on the availability of a core of information in standard formats. Methods of measurement and duties may need to be reviewed to ensure that the appropriate information is produced so that measurement can be automated to a greater degree.
- Cost information can be embedded directly as an object attribute. Alternatively, it can be held in a separate database, linked by item codes.
- Programme simulation is the output typically known as '4D' – which generally describes the simulation of the build sequence. Alternative uses of programme data, such as the production of a cash-flow or the calculation of management costs are less well developed. Software links between BIM and programme applications have been developed in response to these opportunities

Procurement Issues

- Client's ability to define specific BIM requirements as part of an OJEU process. Detailed requirements for technical and technological competence are not perceived to be restrictive and would be permissible under OJEU. Issues of working within existing pre-qualified frameworks such as OGC Buying Solutions where BIM capability is not a pre-requisite have not been considered.
- Client's priorities when appointing a BIM-enabled team. A number of consulted organisations have expressed the concern that the procurement of a BIM-enables team might focus more on the team's technical capability related to BIM rather than the wider skill set related to brief-setting, design and design leadership. In our view, and certainly in the medium term, BIM competence should be dealt with at a pre-qualification stage – so that only teams with sufficient BIM-capability will be put through for later stages of evaluation. This approach should ensure that the assessment of BIM capability is dealt with transparently and also that the final selection is focused on the key dimensions of a most economically advantageous tender – programme, cost and quality.
- Client's ability to require a contractor to adopt and develop a design team sourced model. Larger main contractors have strong BIM capability as do selected parts of the supply chain – (steel, M&E, offsite manufacture). Contractors currently prefer to build their models from scratch. The aim of the BIM Protocol will be to encourage reuse
- Will BIM adoption involve a cost premium? Details are yet to emerge, but costs are estimated to increase by 1% overall, but net savings of 5% on construction cost should be achieved as a minimum. Improved base design information should reduce modelling costs of other team members.
- Are there practical barriers to a lead designer/BIM coordinator role? No but BIM protocols and services drafted to facilitate this process will avoid waste and increase clarity. Elsewhere this group has recommended that the responsibility cascade of design originator and model integrator is clarified. Further recommendations are made concerning the application of quality control standards such as BS1192:2007 to ensure the integrity of the master BIM model
- Issues associated with the transfer of design responsibility to the contractor. This is not considered to be different to current practice.
- BIM Protocols, European procurement regulation and restraint of trade. Some concern has been raised by members of the working group with regards to the compatibility of recommendations aimed at establishing a minimum standard of BIM compliance and European Open Markets regulation. Our view is that the establishment of BIM Competence as pre-qualification criteria will not represent a restraint on trade for the

larger projects identified as being suitable for deliver at BIM level 2. Specific reference has been made to the work of CEN/TC395, which is engaged in work aimed at the elaboration of European Standards on "Engineering Consultancy Services" that apply to the sectors of buildings, infrastructure, industrial units and industrial products. The first strand of work undertaken by CEN/TC 395 is to develop European Standards on terminology – including the standard definition of work packages. After this stage has been completed, a survey will be undertaken to determine whether further standardisation work is required. Our view is that recommendations in connection with BIM – including the establishment of maturity models, Protocols and adapted schedules of services will enhance the development of definitions of services and could potentially contribute to the work of CEN/TC 395.

Approval Processes

- Recording model freezes at gateways. Currently hard copy output is retained at review stages. As models become more sophisticated, the storage issues associated with large BIM models will become more significant
- Additional skills required by clients at gateways. The ability of members of the client team to access the model is desirable. As model outputs become more sophisticated, clients need to focus on decision making based on more options, a wider range of design criteria, and faster turn-around cycles
- Responsibility for confirming accuracy of BIM as record of completed building. Typically this will be the contractor. Use of standards such as COBIE (recommended elsewhere in this report) and the soft landings process based on use of the as-built BIM is the most effective way of facilitating this review. A 3rd party audit may be beneficial ahead of final acceptance. NOTE: no contractual mechanism provides a practical mechanism for the management of the completion of FM and O&M information post beneficial occupation – this may require review.

Resource management issues

- Impact of BIM adoption on resource requirements and fees. BIM adoption results in the front loading of resource requirements, which may need to be reflected in revised fee drawdown agreements. Elsewhere in this appendix we report that preparing design models for use by other parties may increase initial resource requirements by 15% but will generate savings elsewhere. An end to end resource assessment may be needed to find the right balance of fee and effort throughout the design and construction process. Shortcuts at the outset may result in savings in downstream activities.
- Impact of BIM adoption on responsibilities of contributors to the model. Use of BIM at level 2 does not change the balance of responsibilities between members of the project team other than the role of the BIM co-ordinator. Designers will populate a data rich model with specification information rather than preparing a separate NBS or similar written specification. Additional responsibilities related to analysis made need to be set out. Clarification of the hierarchy of design origination, coordination and integration may be needed if a separate BIM-coordinator/model manager is appointed. Working at Level 3 will need greater integration – either a single appointment for an EPC delivery model, an appointment for a single lead-consultant or a multi-party integrated team
- Can cost consultants and contractors rely on models for quantities generated from the model? Information derived from the model will be an accurate representation of the state of development of the model. Techniques need to be adapted to understand the status of the model, derived additional information from the model and to undertake sense checks. Measurement will be accelerated but discretionary skills will still be necessary

- Implications of using off-shore modelling resources. No specific issues so long as the BIM protocol and quality control processes are rigorously applied. PQQ processes may need to account for extent of outsourcing

Alignment with the maturity model

Working Group

Recommended actions

1. Use the matrix to plan a sequence of activities to ensure that objectives to establish BIM level 2 as a standard way of working are met within the 5 year programme

Overview

- This section of the report takes the principle findings and recommendations of the legal, contracts and insurance group and aligns them with the BIM maturity model – demonstrating the actions that need to be taken by the Government Construction Client or by industry to facilitate movement up the maturity curve.
- The results are presented in a tabular form and identify whether the action involves strategies related to either client pull or industry push.

Activity	Push/ Pull	Level 1	Level 2	Level 3
BIM roadmap	Pull	1. Define requirements for managed information exchange between participants	1. Define requirements for information exchange between participants 2. Define requirements for use of outputs during project 3. Define requirements for post-completion use of outputs	1. Define output requirements for integrated model 2. Define requirements for use of outputs during project 3. Define requirements for post-completion use of outputs
BIM roadmap	Push	1. Establish targets and programme for capability to deliver information exchange and reuse 2. Deliver capability as required	1. Deliver capability as required	1. Deliver capability as required
Professional appointment	Pull	1. Draft amendment to enact BIM protocol	1. Incorporate amendment to enact BIM protocol 2. Consider lead consultant appointment	1. Use integrated project team appointment
Construction contract	Pull	1. Draft amendment to enact BIM protocol	1. Incorporate amendment to enact BIM protocol	1. Use integrated project team contract
Schedules of service	Pull	1. Draft duties for model integrator/manager	1. Incorporate duties related to use of the model and extended outputs 2. Draft duties for model integrator/manager	1. Draft duties for appointment of integrated team
BIM protocol	Pull	1. Use protocol based on current 2D/3D exchange standards and project deliverables	1. Standardise BIM protocol requirements as basis for forward development by	1. Use protocol based on fully integrated BIM 2. Protocol describes additional project deliverables based on

Activity	Push/ Pull	Level 1	Level 2	Level 3
		2. Establish single representative group to deliver BIM protocol	supply chain 2. Use protocol based on BIM exchange standards 3. Protocol describes additional project deliverables based on extended BIM capability	fully integrated BIM
BIM protocol	Push	1. Contribute to BIM protocol through direct engagement and capability development	1. Contribute to BIM protocol through direct engagement and capability development	1. Contribute to BIM protocol through direct engagement and capability development
Clarify client copyright requirement	Pull		1. Review current wording of licence for fitness for purpose and revise to extend use of outputs 2. Clarify issues associated with copyright in the model	1. Resolve joint ownership issues. Consider assignment of copyright to owner
Clarify supply chain copyright position	Push		1. Review current practice re licences within the supply chain and revise to extend use of model	
Define model manager role	Push	1. Define review roles required under AVANTI, BS1192:1997	1. Draft scope of services for standalone model manager role for design and construction. Define corresponding services within the project team	1. Draft scope of services for model management as part of integrated appointment
Clarify design responsibility	Pull		1. Amend current agreements and contracts to provide clarity between design origination, coordination and review, and model management	1. See schedule of services for integrated team
Clarify transfer of ownership of model	Push			
Model ownership	Push			
Project insurance	Pull		1. Receive single project insurance proposals as valid alternative commercial proposal	1. Require standard integrated project insurance in base proposal
Consultant and contractor BIM competence	Pull		1. Review and develop standard BIM competence PQQ	1. Review and develop standard integrated BIM competence PQQ

Appendix 6

Processes & Documentation

Introduction

The need to have a consistent set of published documentation is key to common understanding, training and the development of contractual working relationships.

BSi is the primary publisher of standards based documentation in The UK and they have been engaged in the process of developing this strategy. The team responsible for the production of construction related documentation is B/555. This group is chaired by Professor Peter Rebbeck and he has kindly agreed to the inclusion of the B/555 roadmap in this document.

The BSi Roadmap is based on the same maturity matrix as this strategy. The strategic views of both B/555 and the working groups responsible for this strategy have alignment of intent for the delivery of the Level 2 documentation. The production of this material will be produced by a third party (potentially CPIC) and published in the short term by BIS/OGC. Once the material has been in the public domain and in use for a year or so it will be eligible for update and publication as a full BSi "Standard".

In our work with the Institutions it is clear that there is work to be agreed in the areas of "Plan of Work" and specific discipline guidance. The Institutions will be free to update their own material as they see fit and encourage dissemination through their networks.

The contractual relationships between these documents are described in Appendix 5.

The following documents in this appendix describe progress to date:

1. B/555 Roadmap
2. CPIC – B/555 briefing note
3. Briefing note for Construction Design, Delivery and Operations Information Management, Maturity Level 2, Guidance in the creation, maintenance and use of open sharable asset information (to be developed into a specification for delivery).

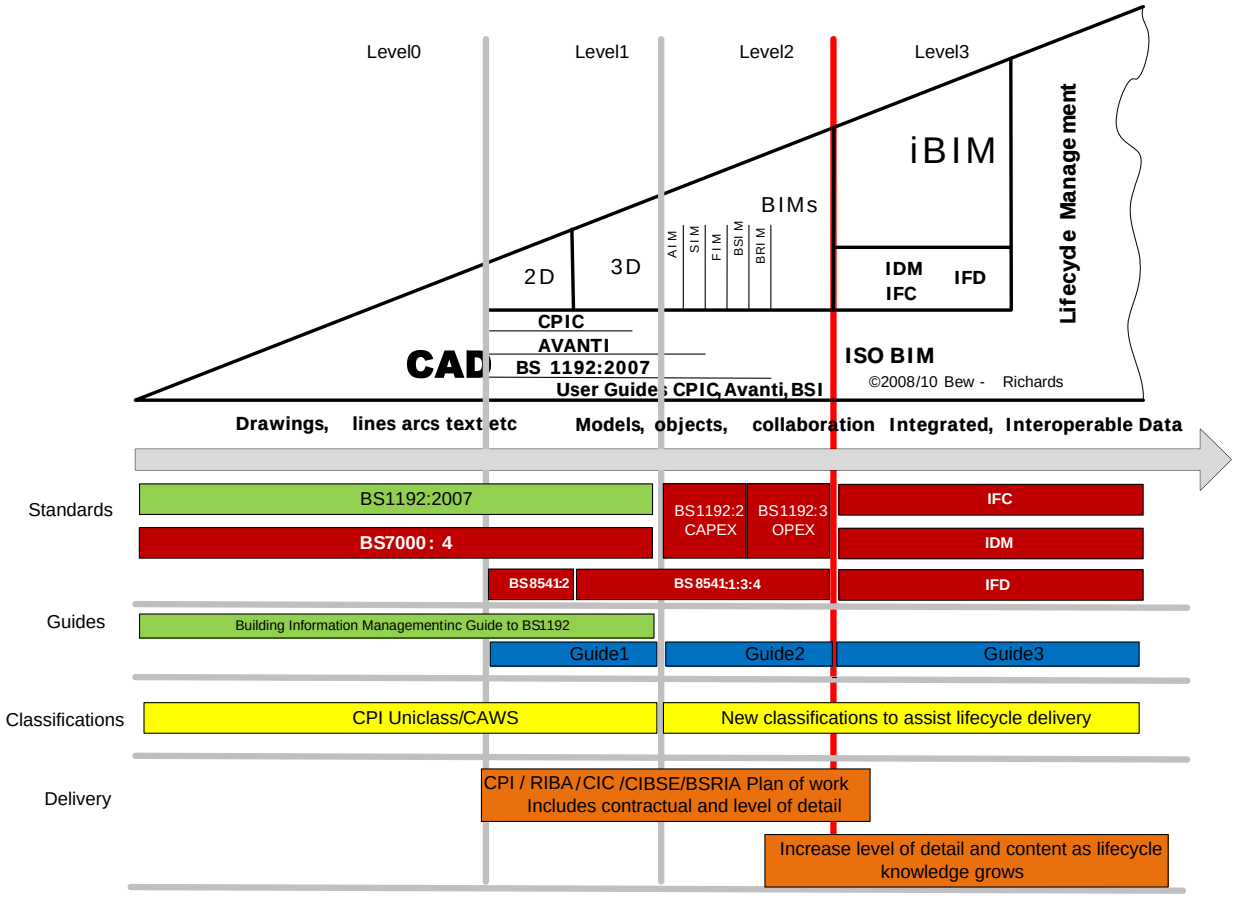
B/555 Roadmap

Design, Construction & Operation Data & Process Management

Introduction

The purpose of this Roadmap is to document and describe the activities of the B/555 committee (Design, modelling and data exchange) in the immediate past, current and future in support of delivering clear guidance to the UK industry dedicated to providing and operating built assets. It also supports the vision and mission statement of the committee in the reduction of whole life cost, risk, carbon and the timely delivery of buildings and infrastructure projects.

To illustrate the process a maturity model has been devised to ensure clear articulation of the standards and guidance notes, their relationship to each other and how they can be applied to projects and contracts in industry.



To simplify the description of technologies and ways of working, the concept of maturity Levels has been defined. The purpose of the maturity levels is to categorise types of technical and collaborative working to enable a concise description and understanding of the processes, tools and techniques to be used, thus allowing simple referencing as to where various documents should be applied.

Standards mentioned in this document:

BS 1192:2007 Collaborative production of architectural, engineering and construction information. Code of practice

BS 7000-4:1996 Design management systems. Guide to managing design in construction

BS 1192-3:1987 (withdrawn) Construction drawing practice. Recommendations for symbols and other graphic conventions

BS 8541-2: (publication due in 2011) Library Objects for Architecture, Engineering and Construction: Recommended 2D symbols of building elements for use in building information modelling.

BS 8541-1: (publication due in 2011) Library Objects for Architecture, Engineering and Construction: Identification and grouping

BS 8541-3: (publication due in 2012) Library Objects for Architecture, Engineering and Construction: Shape and measurement

BS 8541-4: (publication due in 2012) Library Objects for Architecture, Engineering and Construction: Attributes for specification and simulation

Maturity Level Definitions

1. Unmanaged CAD probably 2D, with paper (or electronic paper) as the most likely data exchange mechanism.
2. Managed CAD in 2 or 3D format using BS 1192:2007 with a collaboration tool providing a common data environment, possibly some standard data structures and formats. Commercial data managed by standalone finance and cost management packages with no integration.
3. Managed 3D environment held in separate discipline "BIM" tools with attached data. Commercial data managed by an ERP. Integration on the basis of proprietary interfaces or bespoke middleware could be regarded as "pBIM" (proprietary). The approach may utilise 4D Programme data and 5D cost elements.
4. Fully open process and data integration enabled by IFC / IFD. Managed by a collaborative model server. Could be regarded as iBIM or integrated BIM potentially employing concurrent engineering processes.

The application of standards is dependent on many often poorly understood or articulated factors. The maturity model is used to identify where standards and associated tools and guides are applied to develop a coherent solution to inform the delivery process.

The B/555 Roadmap deliveries are related to the appropriate "Level" for clarity.

Key Road Map Deliveries

Delivery 1 2007/10 - Object Libraries

Items indicated in green are existing documents available in the market today. BS 1192:2007 is a combined data and process standard and is equally applicable at level 0 and 1. It offers advice for the management of traditional CAD managed data delivery and works with both paper and electronic formats. CPI and Avanti have produced guidance to support implementation of BS

1192:2007 and BSI/CPI have jointly published a guide "Building Information Management - A Standard Framework and Guide to BS 1192" in September 2010.

New deliveries from B/555 are an update of the BS 7000:4:1996 to document the overall design coordination process and the planned management of the project data delivery synchronised across all participating disciplines.

Symbol definitions for the presentation of 2D information have not featured in the B/555 document family since the withdrawal of BS 1192:3:1987, this situation will be rectified with the release of BS 8541:2 as described below.

There has never been a consistent set of 3D libraries or definitions in the UK. This is a significant gap as 3D technologies are now commonly available in the market. BS 8541:3 will address this issue.

Now Level 1 defines the use of 2D and 3D CAD tool sets it is appropriate that a consistent set of symbols with the associated guidance in use as appropriate. The documents will be labelled a follows.

- BS 8541:2 Will define 2D symbols and make them available as dwg, dxf and ifc formats. This standard is essentially focussed on levels 0 to 1. The format will be a schematic representation denoting content and/or process. Example: Schematic floor layouts or Process and Instrumentation Diagrams (P&ID).

- BS 8541:1 Will introduce library objects, represented in appropriate formats for use at level 0 (blocks, cells) through to level 3 (IFC objects). The document will refer to BS1192:X and object based principals for identification (naming) and grouping (layering and classifications), it will also include identification of source.

- BS 8541:3 Will define 3D symbols in multiple levels of detail. This is essentially focussed on levels 1 to 2, to represent the analysed and designed output as the first level representation in a real world, they will include functional and geometric quantity measures (volume, projected area, plan area, effective length etc).

- BS 8541:4 Will define properties and multiple levels of information; this will be essentially focussed on levels 2 to 3. The document will include:
    - Properties required for specification/selection
    - Environmental, cost and social impacts (CEN/TC/350 Sustainability of Construction Works)

Delivery 2 2010 – Process and Data Management

Indicated in red are the new standards documents which build on BS 1192:2007 and enable us to make use of the various new technologies. It is clear that as new technologies and collaboration techniques come to market even more clear guidance needs to be made available. This guidance must be specific to its intended audience as the needs of clients, suppliers and users differ significantly. For this reason the documentation with be provided in two documents, the first focusing on the “Capital Delivery” phase and the second on “Operational Delivery” issues. Both will document both data and process management issues. Key issues dealt with will include:

- Process definitions
- Data management for data definitions used for

    - Production & operation
    - Libraries & specifications, properties and representations in various stages
- Generic Delivery Schedules identifying key deliverables at identified stages for all design, delivery and operational disciplines.

It is expected that existing classification and delivery schemes such as the CIC/RIBA stages etc will become compliant with these standards.

The two documents will be labelled as follows:

- BS1192:2 Capital Project Delivery - Processes and data for the requirements, design, procurement stages.
- BS1192:3 Operational Asset Management - Processes and data for the commissioning, handover, operation and occupation stages.

The two documents will deliberately overlap to ensure there is documentation covering the whole lifecycle from end to end. The definition of open data exchange between all stages including construction to operation will be defined.

Delivery 4 2010/12 – Guidance Documents

Guidance documents are not seen as part of the remit of B/555 but as documents that will be delivered in partnership with the British Standards Institution. Example: Building Information Management – A Standard Framework and Guide to BS1192.

With such a complex subject clearly a significant level of clear supporting guidance will be necessary, to ensure consistence and quality, B/555 will coordinate the production of this material. The documents described below are indicated on the Maturity Model in blue.

Guide 1 Level 1

Will offer guidance on the design management to deliver the process and data requirements of BS 1192 and those specified in BS 7000:4.

Guide 2 Level 2

Will offer guidance on the design, data management and the workflow processes to deliver the CAPEX & OPEX standard. The requirements and content as defined in the 'Delivery' documents to be produced by CPI/Avanti. These will contain the coordinated deliverable of each stake holder, architect (RIBA), structural (ACE) civil (ICE) and MEP (BSRIA) engineers against the RIBA/CIC Plan of Work Stages. For the infrastructure works we will include the railway (GRIP) stages.

Guide 3 Level 3

As maturity level 3 becomes a reality and technologies develop into web services and distribution of interoperable data sets a Level 3 Guide will be developed.

October 2010
B/555

Chairman – Peter Rebbeck

Briefing Note January 2011

Construction Project Information Deliverables Management

Prepared by BIS BIM – BS 555 – CPIC

This document for construction deliverables 'Briefing Note' is to be read in conjunction with

- BS 555 Roadmap v6 – October 2010
- CCB(0910) 5 –BIM - Building Information Modelling and Management (BIM) - Interim Report from the BIS/Industry Working Group – September 2010
- CPIC Proposal – Aligning Design Activities and Deliverables – 20 December 2010

Introduction

The purpose of this document is to describe the relationships between a number of industry initiatives in the area of Information and Requirements deliverables management. These are summarised as:

1. The outputs of the BIS BIM work stream 2 which identifies the needs to have consistent delivery of information to manage ongoing downstream transactions.
2. The documented roadmap from BS 555 identifying the need for delivery information to be systemised into a standards document for the delivery of level 2 and 3 of the maturity wedge. (Bew and Richards 2008)
3. The CPIC proposal to produce an aligned plan of work in a similar model to the BSRIA example.

This document does not seek to restate or summarise these documents but to identify a complimentary way forward to deliver a comprehensive usable document which is key to the delivery of useful BIM enabled data sets.

Objective

The production of a usable, consistent set of documents that identify clearly all design inputs and outputs at key stages of an assets life. To include but not be limited to:

- Involvement and agreement of all interested parties, especially institutions and client organisations
- Alignment of delivery stages
- Agreement to the use or otherwise of OGC gates
- Polymorphic (useable and relevant to all players in the supply chain)
- Suitable for use as interim "contract documents" for use in the BIS BIM Quick Wins programme. We may need to discuss getting BIS/OGC to sponsor publication to help this.
- Suitable to be adopted in 12-24 months by the BS 555 committee as the basis of a Standards document (Covering the areas of BS1192:2 and 3, Guide 2 and BS8541:1&3&4).
- To inform the software vendors of the needs of the industry to deliver consistent and coordinated data sets across the disciplines and not just in the vertical silo BIM delivery currently available in the market.

Mark Bew and Mervyn Richards
January 2010

BIS BIM Project

Construction Design, Delivery and Operations Information Management

Maturity Level 2

Guidance in the creation, maintenance and use of open sharable asset information

Introduction and Purpose

The purpose of this series of documents is to support the rollout of the BIS BIM strategy (March 2011). The documents are by design a pre delivery in the form of an eventual BSi sponsored set of standards and guides, with the express purpose of supporting the BIS BIM strategy for private sector work. The documents will also be made available in full in support of clients in the private sector who wish to make use of them.

This document should be read in conjunction with B/555 Roadmap v6.

The roadmap sets out current and future documentation in the context of maturity levels. It is the expectation that the BIS BIM strategy will require the delivery of all public sector works to be at the status of at least "Level 2" within five years. The roadmap identifies the following documents to be produced as part of the Level 2 information set.

- **BS1192:2**
  Capital Project Delivery - Processes and data for the requirements, design, procurement stages.
- **BS1192:3**
  Operational Asset Management - Processes and data for the commissioning, handover, operation and occupation stages.
- **BS 8541-1**
  Library Objects for Architecture, Engineering and Construction: Identification and grouping
- **BS 8541-3**
  Library Objects for Architecture, Engineering and Construction: Shape and measurement
- **BS 8541-4**
  Library Objects for Architecture, Engineering and Construction: Attributes for specification and simulation
- **Guide 2 Level 2**
  Will offer guidance on the design, data management and the workflow processes to deliver the CAPEX & OPEX standard. The requirements and content as defined in the 'Delivery' documents to be produced by CPI/Avanti. These will contain the coordinated deliverable of each stake holder, architect (RIBA), structural (ACE) civil (ICE) and MEP (BSRIA) engineers against the CIC/RIBA Plan of Work Stages. For the infrastructure works we will include the railway (GRIP) stages.

It has been agreed that the fundamental structure of any documents created as part of this exercise will follow this structure to enable the eventual conversion into formal BS standards to be as efficient as possible.

The following is a proposed structure and potential delivery/required dates in accordance with the programme described in the BIS BIM strategy.

Number	Description	BS Reference	Required By
1	Processes and data references for design, procurement and construction	BS1192:2	1
1.1	Terms & References	BS1192:2	1
1.2	Collaboration Management Process	BS1192:2	1
1.3	Library Management Process	BS1192:2	1
1.4	Information Status Definitions	BS1192:2	1
1.5	Information Owners & Responsibilities	BS1192:2	1
1.6	Model Management	BS1192:2	1
1.7	Classifications	BS1192:2	1
1.8	Referencing	BS1192:2	1
1.9	Output Definitions	BS1192:2	1
1.10	Geospatial Referencing and interfaces	BS1192:2	1
1.11	Procurement Processes	BS1192:2	3
1.12	Take Off Processes	BS1192:2	3
1.13	Data Input Processes (inc Cloud, topo etc)	BS1192:2	3
1.14	System Commissioning Processes	BS1192:2	2
1.15	Handover Process	BS1192:2	2
1.16	COBie.xx delivery processes	BS1192:2	1
1.17	Managing data during the briefing process	BS1192:2	3
2	Processes and data for the commissioning, handover, operation and occupation stages.	BS1192:3	1
2.1	Terms & References	BS1192:3	1
2.2	Collaboration Management Process	BS1192:3	1
2.3	Library Management Process	BS1192:3	2
2.4	Information Status Definitions	BS1192:3	2
2.5	Information Owners & Responsibilities	BS1192:3	2
2.6	Model Management	BS1192:3	2
2.7	Classifications	BS1192:3	2
2.8	Referencing	BS1192:3	2
2.9	Output Definitions	BS1192:3	2
2.10	Geospatial Referencing and interfaces	BS1192:3	2
2.11	Procurement Processes	BS1192:3	2
2.12	Data input processes (IP Sensors)	BS1192:3	2
2.13	Data Input Processes (inc Cloud, topo etc)	BS1192:3	2
2.14	System Commissioning Processes	BS1192:3	2
2.15	Handover Process	BS1192:3	1
2.16	COBie.xx delivery processes	BS1192:3	1
2.17	Health & Safety File type information	BS1192:3	3
2.18	Maintenance Updates	BS1192:3	3
	Library Objects for Architecture, Engineering and Construction	BS 8541-1	1
	Scope		1
	Terms & References		2
	Management Process		2

	Security		2
	Identity and Ownership		1
	Liability and IPR		2
	Classifications		1
	Status		2
	Delivery Process		1
	Identification and grouping	BS 8541-1	
	Identifiers		1
	Formats		1
	Versioning		1
	Identification Attributes		1
	Grouping Attributes		1
	Shape and measurement	BS 8541-3	2
	Visual representations		3
	Symbol Representations		3
	Delivery Requirements		1
	Validation attributes		3
	Attributes for specification and simulation	BS 8541-4	4
	etc		
	Overall Implementation Guidance information to deliver useful and concise help to key stakeholders in the supply chain	Guide 2	1
	Clients	Guide 2	1
	Investors	Guide 2	1
	Contractors	Guide 2	1
	Designers	Guide 2	1
	Sub Contractors	Guide 2	1
	Commissioners	Guide 2	3
	Maintainers	Guide 2	2
	Users	Guide 2	2

Appendix 7

Education & Training

Key to any successful change programme is communication of the change and adequate support during the process. We have worked with both vocational, academic institutions and the institutes to identity new ways to face the challenge. All the stakeholders we engaged identified the issue and were keen to work with HMG to change the approach and deliver appropriate training throughout the supply chain and career path. In order to bring about this transition effectively, educational pathways need to be developed that are both inter-disciplinary and span across educational institutions.

Two main pathways are proposed to address on both the client and supply side:

- The next generation of professionals
- Current industry practitioners

The overall philosophy is to integrate BIM within existing education, work based learning and training services rather than to create an additional tier of qualification.

Within our higher education programmes it is recommend that learning outcomes and transferable skills relating to collaborative working and BIM are added to the current requirements of the professional accreditation bodies. These will need to be supported and coordinated by a national body of experts in BIM and education. It is envisaged that this process will take one year to complete and disseminate and will be available for roll out to all HEI's for 2012-2013.

For existing practitioners a work-based learning approach is recommended. This would provide a pathway starting with CPD courses that optionally build through postgraduate certificates and diplomas to masters level qualification. It is recommended that all elements of these educational packages are accepted by our HEI's and that they support the European Credit Transfer and Accumulation System (ECTS) or the European Credit transfer system for Vocational Education and Training (ECVET). This will allow recipients to build their qualifications on a "pick and mix" basis drawing upon a range of national and European BIM and collaborative working skills. This infrastructure would be developed over a three year timeframe in collaboration with HEI's, professional bodies and vocational trainers; it would require coordination to ensure content integration between providers.

A CPD scheme has been developed by the University of Salford and Northumbria are in the process of developing a BIM Hub. Both of these schemes should be developed and a method for ensuring consistency maintained throughout the country. Salford, through a Construction Knowledge Exchange Higher Education to Business (HE2B) Innovation Grant funded project an established education and training development framework was adopted in the development of a BIM awareness, education and training initiative towards the development of industry recognised BIM professionals.

Three packages have been developed specifically focused on building the awareness of BIM. Based on the established framework, each of these 'awareness' packages are targeted at a distinct levels in terms of addressing the key strategic (what/why/business case/how), operational/tactical and technological aspects (supporting tools/technologies), respectively. Each of the packages is structured around the relevant issues of People, Process and Technology readyness.

It is proposed to that the developed material for each of the three packages can be adopted as a basis to take forward in developing the training/CPD element of the BIS strategy. In the first instance, these packages will require reformulating in order to incorporate the push-pull focus of the BIM implementation process within the Strategy along with COBie. Once this material has been developed the various delivery mechanisms will be required to be explored and established before the training/CPD is rolled out."

The research work underway at Reading, Salford, Northumbria and others should be coordinated and links should be maintained with overseas research establishments to ensure our goal of being an international market leader is realised.

	Awareness	Guidance & Toolkits	Web Portal	Training Technical Specific	Training Non technical/ ancillary	Accreditation Tiered structure	Measurement / review / benchmarking	Post Project Evaluation
Client type								
Public	✓	✓	✓	?	✓	✓	✓	✓
Private	✓	✓	✓	?	✓	?	✓	✓
Hybrid	✓	✓	✓	?	✓	?	?	✓
Framework aggregated	✓	✓	✓	?	✓	?	✓	✓
Supplier Type								
Architect	✓	✓	✓	✓	?	✓	✓	✓
Engineer	✓	✓	✓	✓	?	✓	✓	?
Surveyor	✓	✓	✓	✓	✓	✓	✓	✓
Facilities Management	✓	✓	✓	?	✓	✓	✓	?
Contractor / Builder	✓	✓	✓	✓	?	✓	✓	✓
Specialist suppliers	✓	✓	✓	✓	?	✓	✓	?
Manufacturers	✓	✓	✓	✓	?	✓	✓	?

	Sources of Support / Income	Commercial Considerations
Awareness	Institutions Regional BEIN centres Exemplar clients Cons Excellence Best Practice clubs BRE Universities TSB KTN ERDF Tie into other dissemination programmes – such as Nat KPI Sponsorship	This is unlikely to self fund
Guidance & Toolkits	Sponsorship Software suppliers (Cash and kind) Sales of kits and DVDs	Possibly nil? Possibly income generating?
Web Portal	Sponsorship Advertising/ referrals	This is unlikely to self fund
Training Technical specific	Software suppliers (Cash and kind) Course fees Universities Sharing facilities – HEI, BRE, Other training providers. Sector Skills councils	Possibly nil? Possibly income generating?
Training Non technical / ancillary	Institutions (CPD) Course fees Universities Sharing facilities – HEI, BRE, Other training providers. Sector Skills councils	Possibly nil? Possibly income generating?
Accreditation Tiered structure	Software suppliers (Cash and kind) Accreditation fees Licences Tiered levels Call for competition for this?	Possibly nil? Possibly income generating?
Measurement / review / benchmarking	Link to KPI Zone and national suite. Data contract additionally Constructing Excellence Licence fees for online engine module	This is unlikely to self fund
Post Project Evaluation	BRE? Completion Certificate fees. Income from assessor training under accreditation scheme. Outsourcing?	This may progress to self fund

Assumptions are that there will be a national road show and nationwide coverage of events. The material that is required will be created simultaneously for all tiers of support and accreditation. All inception costs are incurred in the mobilisation year.

Appendix 8

Support Structure

Key to any successful change programme is communication of the change and adequate support during the migration process. We have worked with vocational and academic institutions and the various institutions to identity new ways to face the challenge and all are keen to engage in the delivery of this strategy. The recommended solution is a strongly led organisation to exist for the duration of the five year programme, with the express brief to deliver the strategy on time and on budget. The delivery of these tasks is not insignificant and the work packages described in this document covering delivering, strategy, technology, communication, documentation, training and accreditation will need careful scoping and coordination to ensure successful delivery.

It is our recommendation that an independent Stewardship Group will be set up to protect the integrity of the strategy and ensure delivery, this should be coordinated with the Construction Clients Group and the International Alliance groups.

In our research we have not found a single organisation which has a track record of all of these capabilities. We do however favour the route of using the capabilities of an existing (probably public) organisation to host the programme for its duration.

Key immediate organisational tasks will include

- Convene a cross-government 'Implementation and Mobilisation' Task Group, to include representation for local and regional government to:
    a. Identify current capabilities
    b. To consider in details the information needs at key stages and ensure consistency of clarity to the supply chain
    c. Suitable projects on which BIM practice can be demonstrated
    d. To inform the client/industry group on mobilisation
- Invite the client/industry group to develop of a funded mobilisation plan, to include:
    e. Creation, in conjunction with BSI, of an appropriate deliverable scheduling framework
    f. Tailoring of the COBIE methodology for Government requirements (inc Carbon)
    g. Creation of appropriate metrics to monitor outcomes
    h. Consideration of appropriate contractual clauses and requirements
- Act as the central body for 'stewardship' of the work and Communications strategy

Appendix 9

BIM Deliverables

Nigel Fraser

This section attempts to identify what questions a client for a capital project will be seeking to have answered in order for a project to successfully pass through a Project Gateway. It attempts to define what BIM deliverables would enable this with a view to them being included in contracts.

It is generic whilst indicating how it aligns with the CIC/RIBA Outline Plan of Works, GRIP and ICE process descriptions. The work commenced here will need to be completed as part of the mobilisation activities and mapped onto the COBie data definitions at each project stage as well as being completed for later stages. This will form the basis of the data drops described in Appendix 13. An example contract for the procurement of these services, linking deliverables to the NEC3 form of contract is to be found in Appendix 19.

Approximate Project Phases	Question to answer	BIM deliverable (to answer question)	BIM Maturity Level
To OGC Gateway 1 Business Justification (for each option) RIBA Feasibility stage A Appraisal CIC Stage 1 Preparation ICE Project Management Framework (PMF) Gate 0 Strategy TfL CIMM Pipeline	How will BIM be managed and exploited in this project?	A contractual BIM implementation plan for the project defining different levels of design maturity for each project phase, who will develop the content, to what standards, who will be authorised to use it, for what purpose, how it will be coordinated, who will own what and how information inc. libraries and incompatibilities shall be resolved. This is to include the means and protocols for the communication of information between parties. **This is to be reconfirmed for each project phase below.**	1, 2 & 3
	What is the available site?	3D laser, photogrammetric and / or radar survey generated solid model and CDF mesh including ground conditions and existing structures. (May be existing information from a reliable BIM or GIS source) Google maps / OS Maps etc	Optional at any level, 1, 2 or 3 Minimum for Level 1, 2 or 3 or survey needed
	What physical constraints are there on and around the site?		
	What services constraints (water / drainage / electricity) exist?	Existence and current utilisation parameters available for inclusion in a model	All levels if relevant
	What site specific safety considerations need to be made?	Safety briefing information contained in model (EG location of power cables, gas pipes, filled in basements, pits etc). Reference to any existing H&S File or O&M systems. Induction for capex and opex phases	Level 1, 2 and 3 in an appropriate form for the BIM Implementation Plan
	What is the initial view of capital cost?	Model of the development's volumes Schedule of internal volumes, land, floor, wall and roof areas or service runs aligned with generic cost data as aggregated by the cost estimator Fabric not normally represented. Level of detail to be developed	Level 1: from 2D model Level 2 & 3: from 3D model
	What is the initial view of revenue (FM) cost?	Oriented model that minimises energy use. Energy use target or aspiration using an initial environmental performance model Major maintenance and capital replacement costs identified	Level 1: from 2D model Level 2 & 3: from 3D model
	What is the initial view of revenue income?	Schedule of (floor) areas by rental classification	Levels 1, 2 & 3
	How would the development look on the site?	3D Sketch High definition photo rendition of 3D laser survey. 3D solid model overlay onto photo rendition	Level 1 Optional at Levels 2 & 3 Level 3
	How would development control authorities be convinced of the strengths of the development?		
	Will the development meet the flow rate requirements?	People, fluid and or traffic flow model and simulation – spreadsheet based	Levels 1, 2 & 3
	How will logistics requirements be met?	Outline simulation model of people and material flow capacity for the construction phase	Optional levels 1,2,3 Identification of constraints may suffice
	How will security requirements be met?	Outline simulation model of people and material flow capacity for the required security level during construction – spreadsheet based	Optional levels 1,2,3 Identification of constraints may suffice

* AIA = American Institute of Architects Levels of Detail defined in BIM Protocol E202

Approximate Project Phases	Question to answer	BIM deliverable (to answer question)	BIM Maturity Level
To OGC Gateway 2 Procurement Strategy RIBA Stage B Feasibility - Strategic Briefing produced for or by the client CIC Stage 1 Preparation ICE PMF Feasibility Network Rail (NR) GRIP up to 3 option selection TfL CIMM Define Requirements TfL Spearmint Within Initiation	What site information is to be provided?	The survey and associated constraints parametric data from earlier stage	Levels 1, 2 & 3
	What will be the generic services philosophy (passive / natural ventilation / % renewable energy etc)	Generic services philosophy recorded	Levels 1, 2 & 3
	How will design and material quality be defined?	Manufacturers' model information for mandated products (if any) - minimal data for cost, volumetric information, part codes, and relevant performance parameters)	Levels 2 & 3
	Are there any specific FM requirements?		
	How will whole life cost be assessed?	Model information conforming to BS ISO 15686 and BSI PD 156865 to an agreed level of precision	Optional Level 2 Required Level 3
	What format shall the information be delivered to the client in?	Model information compliant with the client's technical standards (or BS1192, BS7000:1, BS8451 or IFC or proprietary format(s)) Using classification codes for building objects as specified or using UNICLASS to AIA*Level of Development: 100	Level 1 Level 2 Level 3 Levels 1, 2 & 3
	How will the outline planning application information be generated?	Drawings, renditions and reports generated from 3D model	Level 1 – from 2D model Levels 2 & 3 – from 3D model

Approximate Project Phases	Question to answer	BIM deliverable (to answer question)	BIM Maturity Level
OGC Gateway 3A Design Brief & Concept Approval End of RIBA Stage C Concept CIC Stage 2 Concept ICE PMF Concept Design NR GRIP 4 Within Single Option Selection TfL CIMM Procure TfL Spearmint Within Initiation	What is the Concept Design?	Rendered block diagram in site context including significant equipment layout, generally to AIA*Level of Development: 100	Level 1 – 2D Levels 2 & 3 3D
	What is the outline proposal for structural design?	Structural design sufficient for simulation modelling for loads, including wind + simulation models & reports Size and weight information in model Temporary construction loads assessed	Levels 1, 2 & 3 – 3D geometry
	What are the output requirements from services systems?	Zoning of services sufficient for first iteration of spatial requirement	Level 1 – 2D Levels 2 & 3 – 3D geometry
	Can the services and structure be combined within the Concept Design within the 3D volumes available?	Combined model to demonstrate the first iteration of coordination	Level 1 – 2D Levels 2 & 3 – 3D geometry
	Can Building Regulations Part L and Energy Performance Certificate Requirements be met?	High level simulation models and reports.	Level 1 – 2D Levels 2 & 3 – 3D geometry
	Can the Client's BREEAM or LEED objectives be met?		
	Has the concept been designed for efficient manufacture and assembly? How easy is it to build?	Modularisation strategy evident in the model. Build sequence recorded in the model. Critical elements of the model designed in detail. Critical logistics routes verified in the model.	Level 1 – 2D Levels 2 & 3 – 3D geometry + time
	What is the preliminary cost estimate?	Schedule of capital costs based upon quantity and rate take off's from the model and an associated schedule of assumptions. Whole life cost assessment based upon this plus in use simulation results and documented maintenance assumptions. (As per BS)	Level 2 Level 3
	How shall the facility be procured?	Recommendations based upon an analysis of the model and associated cost elements.	All Levels
	How will the outline proposals be communicated to the client?	A model with separate layers for structure and services compliant with specified Standards. Ability to provide 3D "walk through" presentation from the primary model. Schedule of facilities included within the development. Generic simulation results for the services philosophy and schedules demonstrating that the brief will be met by the resulting development.	All Levels Level 2 & 3 All Levels Level 2 – associated models Level 3 – integrated model
	How will client specific performance needs be met?	Model based simulations as appropriate.	Level 1 – Calculations Level 2 – associated models Level 3 – integrated model
	How will special presentation needs be met (EG to stakeholders and approvers)?	Combination of the model plus survey, photographic, rendition and time sequenced information as specified by the client.	All levels as a function of what is available from the above.
	Is the cost plan and cash flow forecast reliable and the risk allowance reasonable?	Model containing architecture plus cost and time sequence information.	Level 1 – 2D geometry Level 2 – 3D geometry, associated models Level 3 – 3D geometry +

			integrated model

Approximate Project Phases	Question to answer	BIM deliverable (to answer question)	BIM Maturity Level
OGC Gateway - Intermediate point between 3A and 3B End of RIBA Stage D Design Development CIC Stage 3 Design Development ICE PMF Concept Design NR GRIP 4 Single Option Selection TfL CIMM Procure / Design TfL Spearmint Within Initiation	Is the design developed to demonstrate detailed proposals for: - Coordinated design intentions	UK equivalent of AIA Level of Detail: 200 Zones allocated to demonstrate adequate space for coordination, including building services.	Levels 1, 2 & 3 Level 1 – Calculations Level 2 – associated models Level 3 – integrated model
	- Site layout	Survey of site, Point cloud data processed to form 3D site model. High definition photography overlay on 3D survey.	Level 2 - Optional Level 3 - Required Level 2 - Optional Level 3 - Required
	- Planning & spatial arrangements	Development model superimposed upon 3D laser survey model viewable from a range of pre-agreed perspectives. 2D general arrangement drawings, plans, cross sections and elevations, produced from the 3D model. Schedule of facilities produced from the model.	Level 2 - Optional Level 3 - Required Level 1 – 2D model Levels 2&3 – 3D model
	- Elevation treatment	Rendered model information of the required elevations.	Level 2 -Optional Level 3 – Required
	- Construction systems	Structural information in the model. Envelope information in the model.	Level 1 – 2D model Levels 2&3 – 3D model
	- Environmental systems	Generic services and control systems sizing / capacity information included in the model.	Level 1 – 2D model Levels 2&3 – 3D model
	- Buildability	Optimised construction sequence and programme information developed in the model. Clash prevention confirmation simulations for - Services & structure including profiles, basic specifications & tolerances - Access routes - Lifting operations	Level 1 “extruded 2D to 3D Levels 2&3 – 3D model Level 1 “extruded 2D to 3D Levels 2&3 – 3D model
	Is the cost plan robust (firm)?	Quantity take off from BIM Schedule assumptions based on build sequence used in BIM. Evidence that results of virtual and/or real prototyping of innovative and complex elements of the design have been incorporated into the BIM.	Levels 1, 2 & 3 Levels 2 & 3 Levels 2 & 3
	Is the cash flow forecast reliable?	Sensitivity analysis, varying aspects identified as high risk in the project risk register.	All Levels

	Will the development perform as specified by client's requirements	Model based simulations as appropriate, demonstrating with 95% confidence that the development will perform as required (taking into account the levels of predictability achieved in the past from similar simulations).	All Levels

Approximate Project Phases	**Question to answer**	**BIM deliverable (to answer question)**	**BIM Maturity Level**
OGC Gateway 3B Detailed Design Approval End of RIBA Stage E Technical Design CIC Stage 3 Design Development ICE PMF Within Detailed Design NR GRIP 5 Within Detailed Design TfL CIMM Within Develop TfL Spearmint Within Initiation	Is the design coordinated at a component and building element level of detail?	A detailed model including both geometry and specification information and detailed 2D drawings generated from it. AIA Level of development: 300	Level 1 – 2D Level 2 – 3D associated models Level 3 – 3D integrated model
	Does the design meet statutory standards?	Model with sufficient information to demonstrate a compliant design. Simulations of: - energy use during life and related carbon use calculations - acoustics and PAVA performance - fire & smoke modelling and evacuation - vehicle and people movement capacities	Level 1 – 2D Level 2 – 3D associated models Level 3 – 3D integrated model
	Is the design safe to construct?	Model includes construction sequence and identifies working at height and edge protection. CDM driven activities	Level 1 – 2D Levels 2 – 3D associated models Level 3 – 3D integrated model
	Is the design safe to use?	3D "walk through" for stakeholder assessment.	Level1 – 3D sketch Level 2 – 3D associated models Level 3 – 3D integrated model

Approximate Project Phases	Question to answer	BIM deliverable (to answer question)	BIM Maturity Level
OGC Gateway 3C: Detailed Design Approval End of RIBA Stage H Preconstruction (to Tender Action) CIC Stage 4 Production Information NR GRIP 5 Detailed Design TfL CIMM Within Develop TfL Spearmint Within Initiation	Is the information presentable so as to obtain statutory approvals?	To be developed – Refer to the "Planning Portal" project?	TBA
	Is there sufficient site information available to achieve a reliable tender?	3D model based on laser scan survey (optionally including high definition photographic overlay).	Levels 0 & 1 Level 2 optional Level 3 requirement
	Is there sufficient design information to get a reliable tender (model, drawings, specifications, schedules, room data, bills of quantities etc)?	5D model with both geometric, specification and performance data, with confirmation of the absence of clashes between building, structure and services. AIA Level of Development: 400	Level1 – 2D model Level 2 – 3D associated models Level 3 – 3D integrated model
	Is there a means of controlling distribution of documents?	Definition of how the nominated supplier shall communicate and obtain responses from the client. New Level 2 BS1192	All levels

NB If "design & build" this table requires validation to ensure that the information is appropriate for either use as "employers requirements" or "contractors proposals".

Appendix 10

What is COBie?

COBie is a vehicle for sharing predominantly non-graphic data about a facility. The primary motivation for the use of COBie is to ensure that the Client as Owner, Operator and Occupier receives the information about the facility in as complete and as useful form as possible. Wherever possible, data should be recorded within COBie. The COBie dataset can additionally act as a guided index to the supplementary documentation, including 2D and 3D information.

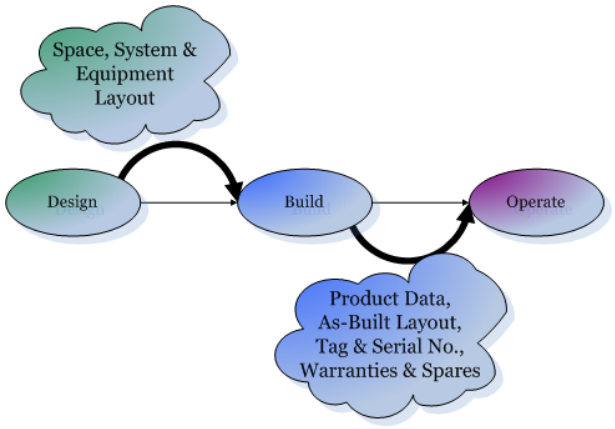
COBie[2] was created to provide a means for the faculties industry to communicate information about facilities so that the client can immediately take full and responsible ownership. It arose from the collaboration of the US Department of State, US Army Corps of Engineers, NASA, and the Veterans Association. In 2008 it was revised as COBie to ensure that it was relevant to facilities worldwide and was fully compatible with international standards for data and classification. Adopters of the COBie approach also include public and private owners, University of Indiana, University Southern California, in the UK Vinci Construction Ltd, and in Germany, The State of Bavaria.

COBie is a non-proprietary format based on a multiple page spread sheet. It is designed to be easily managed by organisations of any size and at any level of IT capability, allowing each of them to contribute efficiently to a single representation of the asset. It requires only information that is (or should be) available anyway, so it does not represent a change in the expected content, only in its usefulness and accessibility. The intent is to not create information that is not already available or produced as part of the existing processes. The aim is to structure and rationalise the information for re-purposing and use downstream. COBie also acts as an index to other documents. Overall COBie provides traceability and visibility of design, construction and handover decisions to all supply and client side stakeholders.

COBie is used for communication, as a means of information exchange between parties, particularly to the customer. Where automation is not in use, such as in the lower tiers of the supply chain, COBie information can be captured using direct entry into the spread sheet, often using cut-and-paste from existing schedules and documents. Parties including the client can use the COBie format as a primary document for managing the asset. Design development, construction management and asset management applications have had no difficulty in interfacing with the format.

COBie comprises sheets that document the facility, the levels (or sectors), spaces and zones that make up the function of the facility. These are then filled with the actual manageable systems and assets and details of their product types. During construction and installation these are amplified with information about the spares, warranties, and maintenance requirements. Throughout the process additional attributes, issues and documents can be associated to all these items.

[2] COBie (Construction Operations Building information exchange) was developed by a number of US public agencies to improve the handover process to building owner-operators.



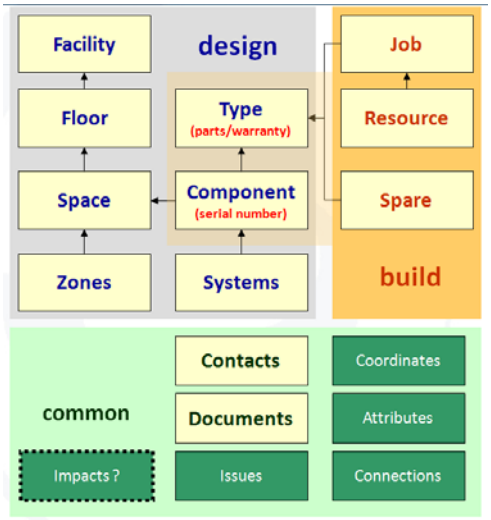
COBie data is accumulated throughout the life cycle

COBie transfers the information needed by the owner/operator to manage their asset efficiently. The principal use-case is therefore the handover of a facility after commissioning of the owner/operator. Typical questions answered by COBie include:

- What is the design performance of my asset? Energy, rental, quality measures,
- What is the amount of floor space of estate? Classified by building type.
- What is the occupancy level of my estate/per building?
- What is the required plant and equipment maintenance scheduling – preventative and reactive?
- What is my operational cost expected to be?
- What is my as-designed energy use cost expected to be? What is my actual energy use?

The use of COBie in practice has shown that it is not limited and has a more general role of communicating the key information in a structured format. COBie has been found to be useful and efficient in many scenarios, including documenting existing facilities.

1. The handover of a facility to the owner/operator.
2. The capture of commissioning and survey information.
3. The reporting of the designed project ready for tendering.
4. The coordination of maintenance records of existing infrastructure.
5. The documentation of issues discovered throughout the life cycle.
6. The delivery of product data.
7. The reporting of design intent at the early design stage.
8. The comparison of briefing requirements against the designed and as built

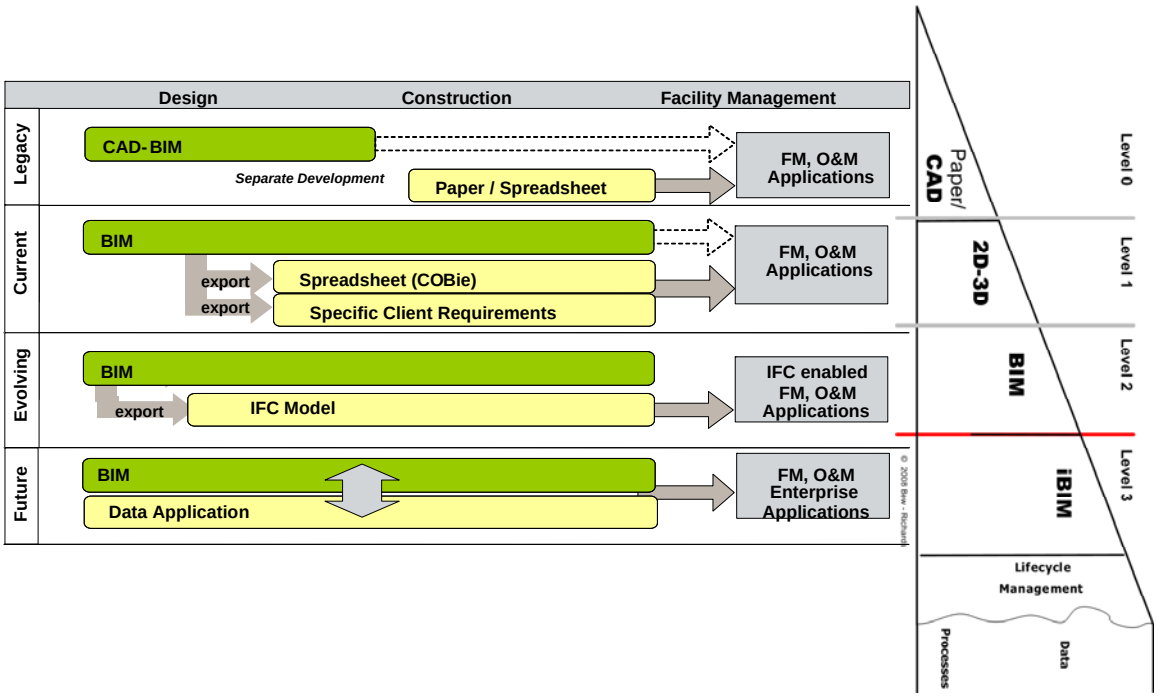


COBie documents the asset in 16 consistent and linked sheets

We anticipate that our application of COBie will develop as the various technologies in the market mature, broadly in line with our "maturity levels model" described in appendix 3. For the majority of the five years of the life of this strategy we anticipate that most of the market will be engaged in or around level 2. For all deliveries at this level, COBie will be adequate as a transport mechanism but may well require additional development to cope with additional attached data, which some clients may start to wish for collection. There will also be a need to have a more robust system for processing the information as our understanding and needs grow. For this reason we have identified a stage where we would hold all delivered data in a database to enable these processes. This will need additional guidance as there would be a need to synchronise data, COBie, calculations and proprietary information at the same point in time.

Our final vision for the delivery of this information will be a fully web enabled transparent (to the user) scenario, based on the Building Smart IFC/IDM and IFD standards.

The model below illustrates this progression, with respect to maturity level.



Appendix 11

Handover Information

Adam Matthews

This appendix details and recommends how handover can be improved for clients through the delivery of consistent and structured information to enable public assets to be maintained and operated.

In order to improve the measurement and management of public assets, the strategy recommends that public clients request specific information be delivered by the supply chain at key defined points in the delivery process. This recommendation draws on best practice observed in the US, which witnessed an improvement of the supply chain's adoption of BIM and the benefits accrued by public clients.

The specified information set, called COBie[3], delivers consistent and structured asset information useful to the owner-operator for post-occupancy decision-making. This 'information delivery' approach effectively insulates the public client from process complexity, technology change and competitive issues – which remain in the supply chain.

During the mobilisation phase of the programme the client specified information set, COBie, will be localised for UK purposes to support carbon related decision-making; and extended to accommodate the requirements of public infrastructure owners. The mobilisation team are recommended to identify specific 'information use' examples to inform client decision-making, and to support clients for the maintaining of the public asset information.

[3] COBie (Construction Operations Building information exchange) was developed by a number of US public agencies to improve the handover process to building owner-operators.

Recommendations for Improving Information Handover to Clients

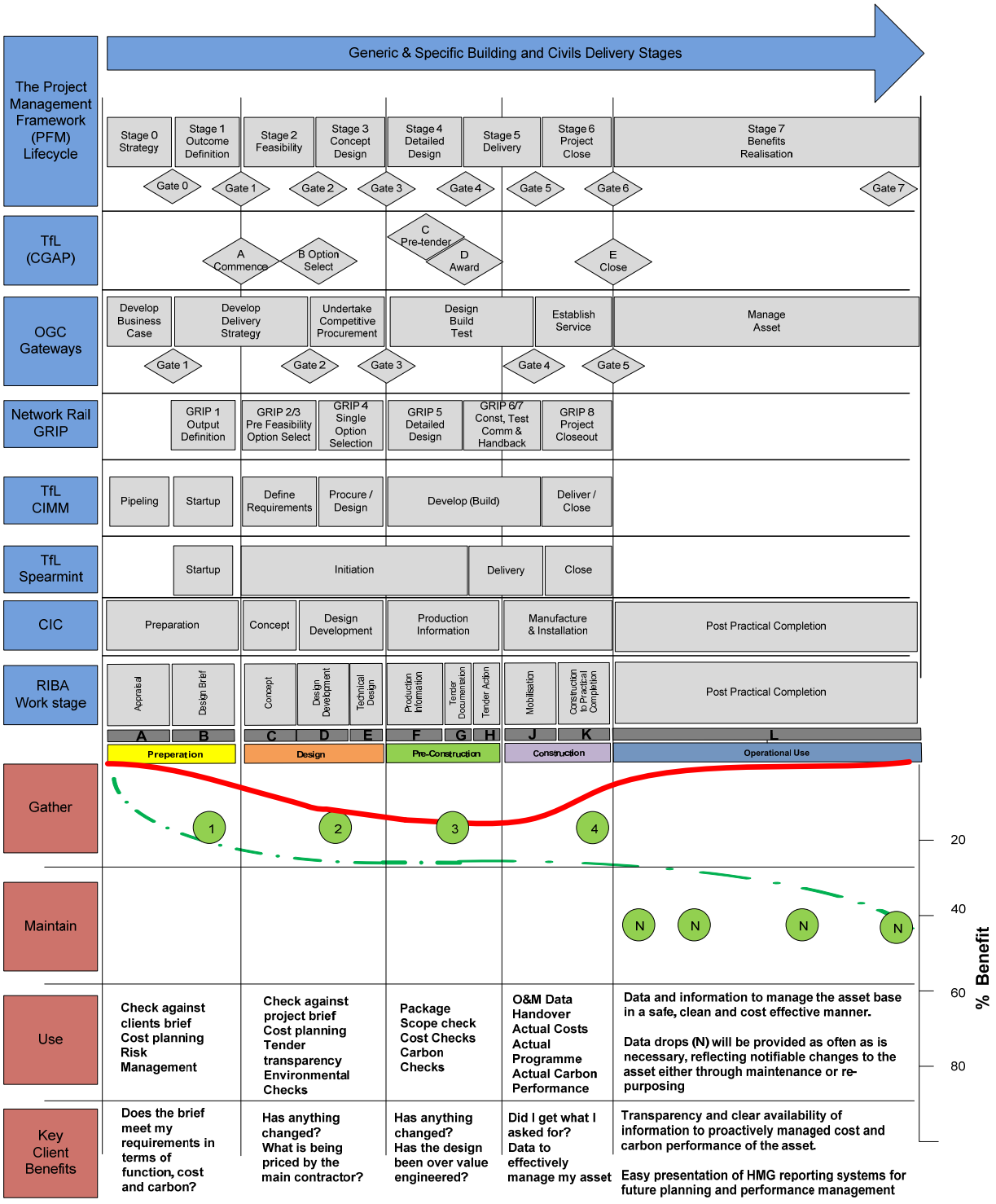
Information Delivery Overview

In order to enhance clients' ability to measure and manage assets we recommend that clients are consistent in their request for information from the supply chain during the asset lifecycle. This report recommends a progressive improvement to the method of information delivery, and the quality and quantity of information handed over to clients as well as placing the requirement to deliver digital data in a pre described format (COBie).

To implement the strategy of progressive improvement of data exchange between clients and supply chain a three phase approach is recommended. Firstly, the strategy improves the process by which information is requested and exchanged between supply chain and clients. Secondly, the strategy enhances the quality and scope of information delivered by supply chain. Finally, the strategy demands more from the supply chain in both information quantity and delivery method (Table 1).

Phase	Change in 'how information is delivered'	Change in 'what information is delivered'	Information Delivery method	What is delivered
One	Medium improvement to the way information is requested and delivered by and to clients	Small improvement to the amount and quality of information delivered by supply chain	BIM information supplied in Microsoft Excel	Cost and carbon operational information
Two	Small improvement to the way information is requested and delivered by, and to clients	Medium improvement to the amount and quality of information delivered by supply chain	BIM information supplied in Microsoft Excel	Whole life cost and whole life carbon
Three	Large improvement to the way information is delivered by, and to clients	Medium improvement to the amount and quality of information delivered by supply chain	BIM information supplied in international standard spatial format	Spatial information

Table 1: Progressive improvement to information delivery


Generic & Specific Building and Civils Delivery Stages
The Project Management Framework (PFM) Lifecycle
Stage 0 Strategy
Stage 1 Outcome Definition
Stage 2 Feasibility
Stage 3 Concept Design
Stage 4 Detailed Design
Stage 5 Delivery
Stage 6 Project Close
Stage 7 Benefits Realisation
Gate 0
Gate 1
Gate 2
Gate 3
Gate 4
Gate 5
Gate 6
Gate 7
TfL (CGAP)
A Commence
B Option Select
C Pre-tender
D Award
E Close
OGC Gateways
Develop Business Case
Develop Delivery Strategy
Undertake Competitive Procurement
Design Build Test
Establish Service
Manage Asset
Gate 1
Gate 2
Gate 3
Gate 4
Gate 5
Network Rail GRIP
GRIP 1 Output Definition
GRIP 2/3 Pre Feasibility Option Select
GRIP 4 Single Option Selection
GRIP 5 Detailed Design
GRIP 6/7 Const, Test Comm & Handback
GRIP 8 Project Closeout
TfL CIMM
Pipeling
Startup
Define Requirements
Procure / Design
Develop (Build)
Deliver / Close
TfL Spearmint
Startup
Initiation
Delivery
Close
CIC
Preparation
Concept
Design Development
Production Information
Manufacture & Installation
Post Practical Completion
RIBA Work stage
Appraisal
Design Brief
Concept
Design Development
Technical Design
Production Information
Tender Documentation
Tender Action
Mobilisation
Construction to Practical Completion
Post Practical Completion
A
B
C
D
E
F
G
H
J
K
L
Preperation
Design
Pre-Construction
Construction
Operational Use
Gather
1
2
3
4
Maintain
N
N
N
N
20
40
60
80
% Benefit
Use
Check against clients brief
Cost planning
Risk Management
Check against project brief
Cost planning
Tender transparency
Environmental Checks
Package Scope check
Cost Checks
Carbon Checks
O&M Data Handover
Actual Costs
Actual Programme
Actual Carbon Performance
Data and information to manage the asset base in a safe, clean and cost effective manner.
Data drops (N) will be provided as often as is necessary, reflecting notifiable changes to the asset either through maintenance or re-purposing
Key Client Benefits
Does the brief meet my requirements in terms of function, cost and carbon?
Has anything changed?
What is being priced by the main contractor?
Has anything changed?
Has the design been over value engineered?
Did I get what I asked for?
Data to effectively manage my asset
Transparency and clear availability of information to proactively managed cost and carbon performance of the asset.
Easy presentation of HMG reporting systems for future planning and performance management
Key
X
Data Drops
Data Management
Industry Delivery Stages
Savings Achieved
Anticipated Savings

At the implementation level this strategy relies on three primary functions being delivered and executed by both clients and supply chain:

1) **Gathering** of public asset information is consistent, structured and comprehensive

2) **Maintaining** the information gathered about public assets is critical to ensure client decision-making is based on accurate and up-to-date data

3) Clients must be **Using** information to support decision-making in order that the strategy successfully delivers the aims of the programme.

The Figure above aligns the delivery processes documented in the various industry plans of works and identifies when data deliveries should be made. Also indicated are key questions and likely benefits to be accrued at each stage of delivery. Our Goal is to achieve the green line in terms of deliverable benefit.

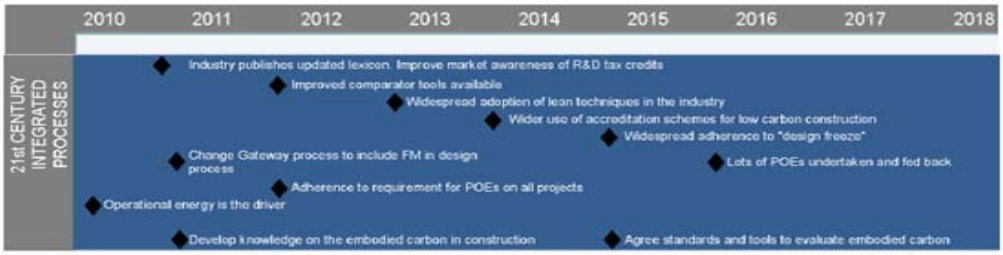
These functions are critical in order to develop a 'virtuous circle' (Carbon Trust, 2009) where asset owners improve decision-making. The implementation recommendations for these three functions (*Gather, Maintain* and *Use*) are described below.

Implementation recommendation to Gather Information

The working group recommends that Government clients mandate the supply chain to deliver public asset information in a specific structured and consistent format, referred to as the COBie[4] format. This specified information set, COBie, is requested of the supply chain at key stages through the asset lifecycle to support decision-making by the client during the construction phase and through the operation and maintenance phase of the asset.

During the mobilisation phase of the BIS programme the COBie format will be amended for UK requirements to include support for carbon related decision-making; and extended to accommodate the specific requirements of public infrastructure owners. This extension is required owing to its original development for building asset owners.

The working group specifically recommends that during Phase 1 of the roadmap that only carbon information related to operational energy and carbon are included for building assets only. For example, this may include Energy Performance Certificate (EPC) and Display Energy Certificate (DEC) related information. Phase 2 would include embodied carbon information to support 'whole life carbon' related decisions that consider the total 'lifetime' amount of energy and carbon consumed and emitted by materials or products. This recommendation is based on the maturity and standardisation of operational and embodied carbon related information and decision-making for building assets. Furthermore it adopts a position aligned with the IGT's *Low Carbon Construction Report* (2010), refer to



[4] COBie (Construction Operations Building information exchange) was developed by a number of US public agencies during 2005 – 2008 to improve the handover process to building owner-operators.

Figure 1: IGT Low Carbon Construction Roadmap – Carbon

The working group recommends for infrastructure assets that both the operational carbon (carbon emitted through operation of the asset) and the capital carbon (equivalent to embodied carbon in buildings, including the construction phase carbon emitted) are investigated further during the mobilisation phase. The information standardisation and use of this infrastructure carbon metrics is immature in the industry; and while the leadership clients in the industry may forge ahead *gathering* this carbon information – this strategy aims to set targets for the trailing edge. Therefore the current recommendation is to not include infrastructure carbon information during Phase 1 of the roadmap and to consider its inclusion in Phase 2 (Table 2).

The mobilisation project for delivering the roadmap will finalise the information to be passed from supply side to client using the COBie format to transport the information.

Phase	**Buildings**	**Infrastructure**
One	Operational carbon metrics	Exclude carbon metrics
Two	Embodied carbon metrics	Consider maturity of industry's use of operational and capital carbon metrics
Three		Operational and capital carbon metrics

Table 2: Phasing introduction of carbon metrics

Above, this report recommends what information to *Gather*. This report refers the reader to the Data Management work stream for recommendations on the systems and processes used to transfer information between client and supply side. Next, this report outlines the implementation recommendation for the *Use* of information (by clients) and how public asset information be *Maintained*.

Spatial Location and spatial hierarchy: we can recommend that as a minimum for both building and infrastructure:

- Components (assets) are named as the target of operational and maintenance activities
- Spaces (workplaces) are named as the location of operational and maintenance activities
- Coordinates are given for these workplaces and assets
- Latitude, longitude and elevation be given for the facility.

Implementation recommendation to Use Information

A critical success measure of the programme is the extent to which clients *Use* the information that is delivered to them for reporting and decision-making purposes. The working group has identified three primary divisions of '*information use*' for owners of assets:

- Reporting
- Operational Decision Support
- Strategic Decision Support

Reporting requirements may include; regulatory, financial or performance benchmarking related asset reports. For example:

- Report the key carbon metrics during design stage of all 8 academies in programme XYZ
- Report floor space across the estate by building type and occupancy level

Operational decision support may include; improving access to key information for maintenance jobs thereby reducing the cost of operations. For example:

- What is the recommended equipment maintenance schedule for installed heating system?

Strategic decision support may include; providing asset information relating to large operational expenditure or capital expenditure. For example:

- How do we utilise the estate more effectively?
- How does the actual 'in-use' performance of the asset compare to the design performance?

In summary, the mobilisation stage will develop and expand this example set of uses for the information provided to clients. The working group recommends that the mobilisation phase engages with a small number of public clients within the Construction Client Board to identify the *Reporting, Operational* and *Strategic* level information requirements.

The working group refers the reader to the 'Delivery Standards' work stream for further information on potential 'use cases'[5] for the information from a client perspective.

Implementation recommendation to Maintain Information

Maintaining information is an important aspect of retaining its value and benefit to the end user of the information. If information is not maintained properly, for example if it becomes out-of-date and not reflective of the real world state of an asset, then its value diminishes. If it is out-of-date, the information cannot be confidently relied upon. Therefore well-maintained information is an important aspect of the recommendation.

Data storage, data sharing, access permissions to data and updating of data are considered in detail in the Data Management work stream report. This working group recommends that the mobilisation phase provide support to clients for how information is maintained and managed in order to retain accurate and up-to-date asset records.

Building & Infrastructure Capabilities

A key requirement of the Hypothesis and the tests was to be "General", by which we meant it would be equally applicable to both the building and civil/infrastructure markets including linear structures. It is true to say that the majority of the work done to date using COBie including that by our American colleagues has been in the buildings arena. However the standard was conceived as "general" and we have done initial feasibility tests using existing data and while some work will be required during the mobilisation stage the system fundamentally copes with both project types. Appendix 12 details the results of the COBie infrastructure tests and key items work that will need to be attended to during mobilisation.

Conclusion

[5] Use cases refer to the scenarios where a person or functional role would perform a process to make a decision.

This strategy, of progressive improvement of information delivery, supports these specific aims of the BIM programme:

- Providing clients information for whole life cost, carbon and value improvement.
- Insulating clients from complexity, technology change and competition issues which remain with supply chain.
- Increase the adoption of, and the derived benefits from, BIM practices in the supply chain and clients.
- Taking small progressive steps to allow systems, processes, legal, training and related cultural changes to be effectively communicated and adopted on both supply and client side.
- Creating a clear target of acceptable performance for the industry's 'trailing edge' over a five year period.

In conclusion, to improve the measurement and management of public assets, the strategy recommends that public clients request specific information be delivered by the supply chain. This recommendation draws on best practice observed in the US, which witnessed an improvement of the supply chain's adoption of BIM and the benefits accrued by public clients[6].

The specified information set, called COBie, delivers consistent and structured asset information useful to the owner-operator for post-occupancy decision-making. This 'information delivery' approach effectively insulates the public client from process complexity, technology change and competitive issues – which remain in the supply chain.

During the mobilisation phase the client specified information set, COBie, will be localised for UK purposes to support carbon related decision-making; and extended to accommodate the requirements of public infrastructure owners. The mobilisation team are recommended to identify specific 'information use' examples to inform client decision-making, and to support clients for the maintaining of the public asset information.

[6] The US, the GSA requested specific BIM deliverables, such as spatial and attribute models, which contributed to growth in adoption of BIM practices.

Appendix 12

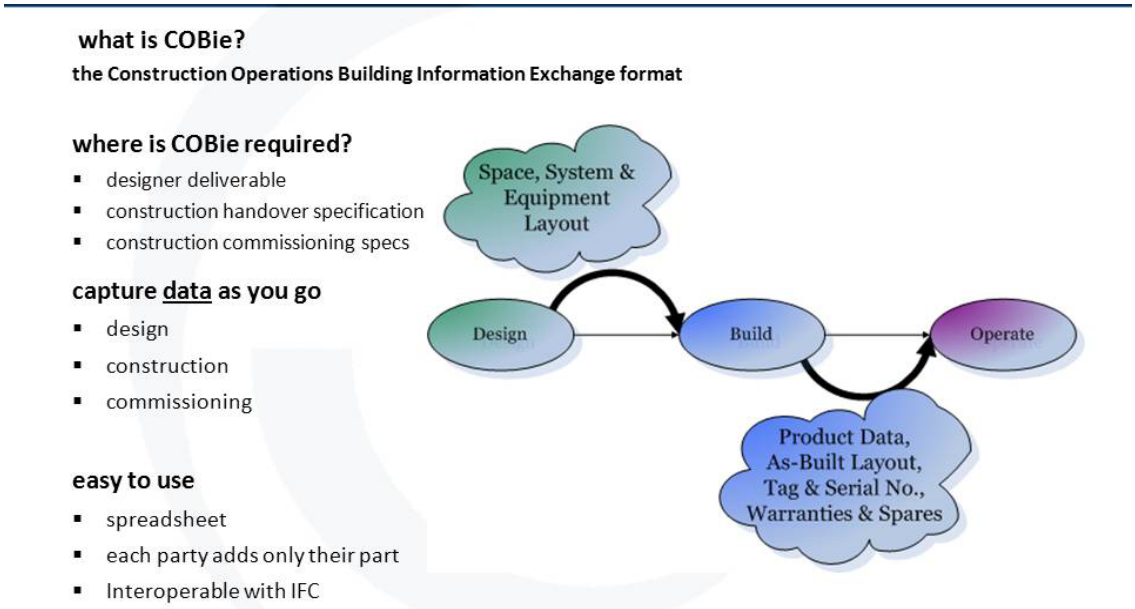
Technical Review of the use of COBie in Civil Engineering and Infrastructure Handover
Nick Nesbitt

It was found that whilst major clients such as BAA and HA (Highways Authority) expect a comprehensive handover, in general Civils/Infrastructure (C/I) handover is done to a far lower standard, if at all. Evidence for this weakness is provided by the high amount of re-surveying and re-inspection that is undertaken after handover. Unfamiliarity with best practice for information handover may make COBie seem an additional task, whereas in the building sector much of the effort in preparing COBie datasets replaces effort that would have gone into other tasks. Ironically once data is collected infrastructure owners often tend to make far more effective use of the information than building operators.

BAA and HA have specific handover requirements, which can include the requirement to handover dataset already structured to their specific CAFM applications. The BAA requirements are specific to the construction arm. The HA requirement is included in the requirements of the MCDHW (Manual and Contract Documents for Highway Works). A deeper review would examine these systems, but the point can be made that by imposing a local or proprietary solution, these larger enterprises may reduce the chances of common standards such as COBie being adopted.

Vinci has responsibility for some significant infrastructure and is using COBie to manage the onsite inspections, and photography relating to the complex and overlapping structures. This is an example where poor handover has had to be remedied afterwards by creating a COBie dataset.

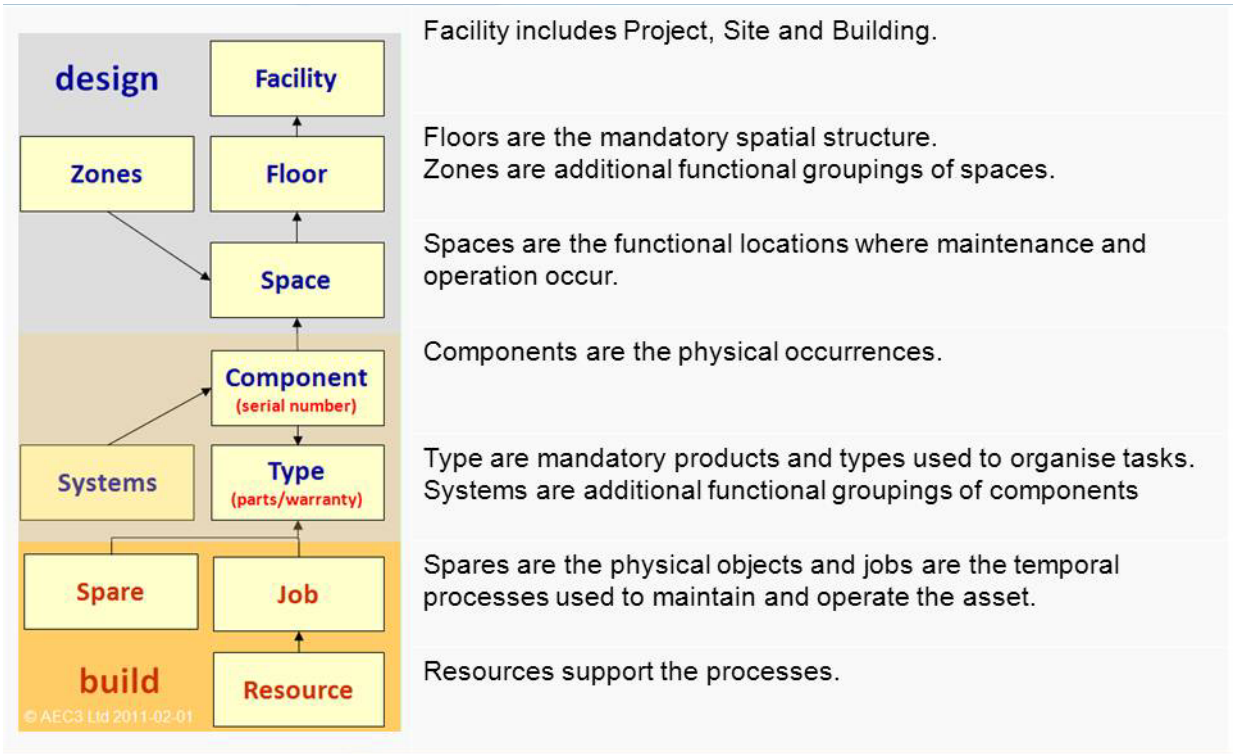
The image below emphasises that the development of a COBie dataset is a continuous process with contributions coming from consultants and from the contractor, sub-contractors and suppliers. The ease of use comes from making the spread sheet template available as the simplest possible low-cost universal interface. Other interfaces have been developed by service and software providers.



COBie dataset is created in a continuous process. (ERDC)

How does COBie represent the facility?

COBie represents the facility as a simple arrangement of familiar concepts. The initial design is represented by a single named 'facility' which is then decomposed into 'floors' and 'spaces'. 'Zones' may be used to represent other collections of spaces for functional purposes – such as access, cooling, fire control etc. The physical components of the facility are assigned to 'spaces', and are grouped by 'Type'. 'Types' are often product types. 'Systems' may be used to represent other collections of components for functional purposes, such as 'substructure', 'structure' and 'deck'. 'Jobs', such as 'inspections', and 'Spares', such as 'luminaries', are assigned to the 'Types' The prerequisite 'Resources' are assigned to 'Jobs'.



COBie represents the overall structure of the facility. (AEC3)

The principal of breaking down a facility into sub-sections is recognised in most C/I projects. Road and rail projects may be seen purely in terms of a single linear extrusion without any break down into sub-sections, except by chainage distances. These may be broken down into Roadway, Intersections, Minor roads, Site and Structures etc.

Conclusion 1: The structure of COBie

The structure of most Civil and infrastructure projects can be represented in COBie as it exists.

Where C/I projects are broken down in this way, 'floor' is an uncomfortable synonym for 'block' or 'sub-section' even though these terms all serve to produce a single non-overlapping breakdown of the facility. BS1192:2007 anticipated that building and C/I projects will both be broken down in this way. Similarly 'space' which in COBie is considered as the destination where operation and maintenance may occur, is not a natural term in C/I projects, where 'Location' might be more recognisable. The names 'Component' and 'Type' are less resonant in C/I projects, where much

of the physical installation may be homogenous materials and extrusions, and specifications may be unique to a single occurrence. However there are discrete objects such as beams, columns, panels and piles, which are discrete assets that are managed and monitored, often to a far higher degree than in building facilities. The difficulty may be in finding equivalent terms that are acceptable in building, C/I and costing disciplines.

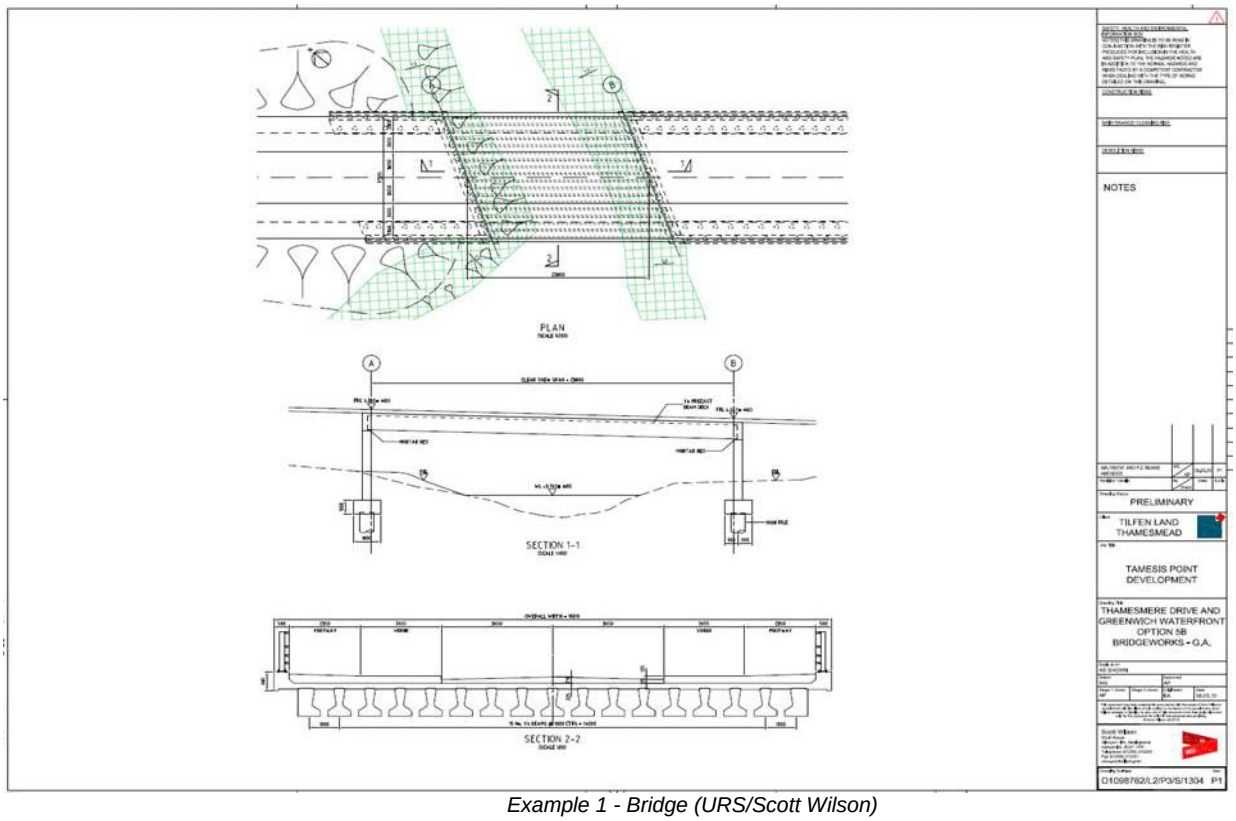
COBie has been designed to be delivered without user applications which would normally conceal differences in terminology. Changing the terminology used could disable those existing applications that already support the COBie standard and reduced the market for new applications. Future applications may be able to cope with differences in naming at the user level.

Conclusion 2: Training COBie

A key part of any COBie training will be to take consultants and contractors out of their usual environment to view the wider handover problem, and appreciate industry processes in general. A new contractual deliverable to support C/I maintenance management is critical. The specific terms ('floor' and 'space') may need generalisation or replacement for C/I.

Example 1

The example provided was a drawing of a small bridge, albeit part of a much larger master planning project. It is not the intention of COBie to reproduce the 2D or 3D content of such a drawing, but the example was useful in speculating about what the structure of the facility is, both spatially and physically.



Example 1 - Bridge (URS/Scott Wilson)

Review of the drawing and application of the principals discussed above, allowed the identification of the Facility and a pragmatic allocation of Floor (divisions) and Spaces. Close inspection also allowed the identification of several Components and some Types. These are summarised in the table below.

Note: Some Components, such as the finished ground and the deck construction, probably don't have a finite extent. This is not an issue since COBie does not hold geometric information. There is

a proposed extension to IFC schema to represent Bridges that could hold the 3D or 2D content of the drawing.

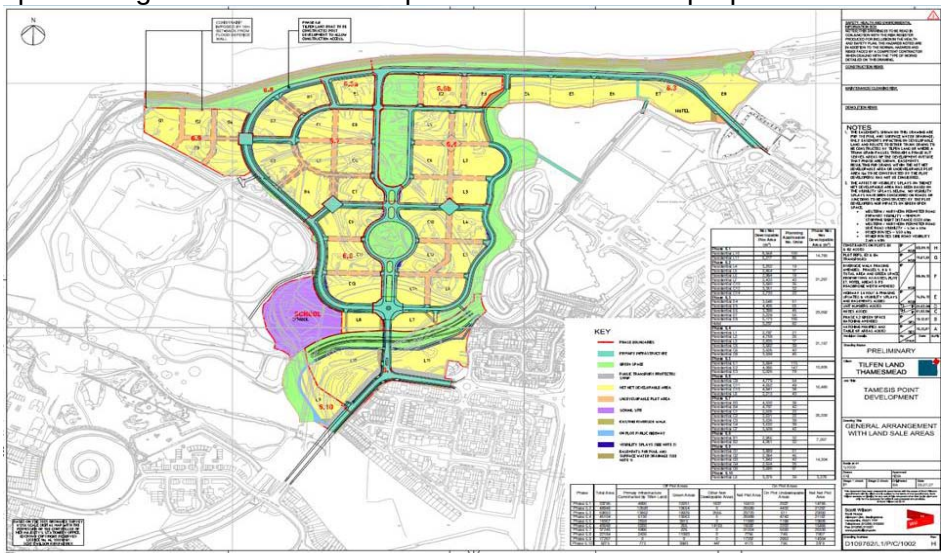
Mapping the overall structure of the Bridge to COBie (AEC3) Note that the physical 'Components' can be assigned to work areas ('Spaces') such as Embankment A.

Conclusion 3: Bridge example

A bridge is not far removed from a building in its data structure and design processes, COBie can be used to document it for handover.

Example 2

The example provided was a drawing of a master plan for a large area. Again, it is not the intention of COBie to reproduce the 2D or 3D content of such a drawing, but the example was useful in speculating about what is the spatial structure of the proposal.



Example 2 – Master planning (URS/Scott Wilson)

Review of the drawing and application of the principals discussed above, allowed the identification of the Facility and a pragmatic allocation of Floor (divisions), Spaces and Zones. These are summarised in the table below.

Examination of data exchange formats such as LandXML and GML confirms that there is not a common consistent breakdown of projects or facilities. These formats allow the communication of individual objects, such as land patches, surfaces, roads and so on, but have little ability to represent any relationship or hierarchy between them. In general there is no consistent structuring in use.

Mapping the overall structure of the master plan to COBie (AEC3). The land parcels such as 'residential b1' are documented as 'Spaces' and are then grouped to make up the main phase ('Floor') and subdivisions of the main phase ('Zones').

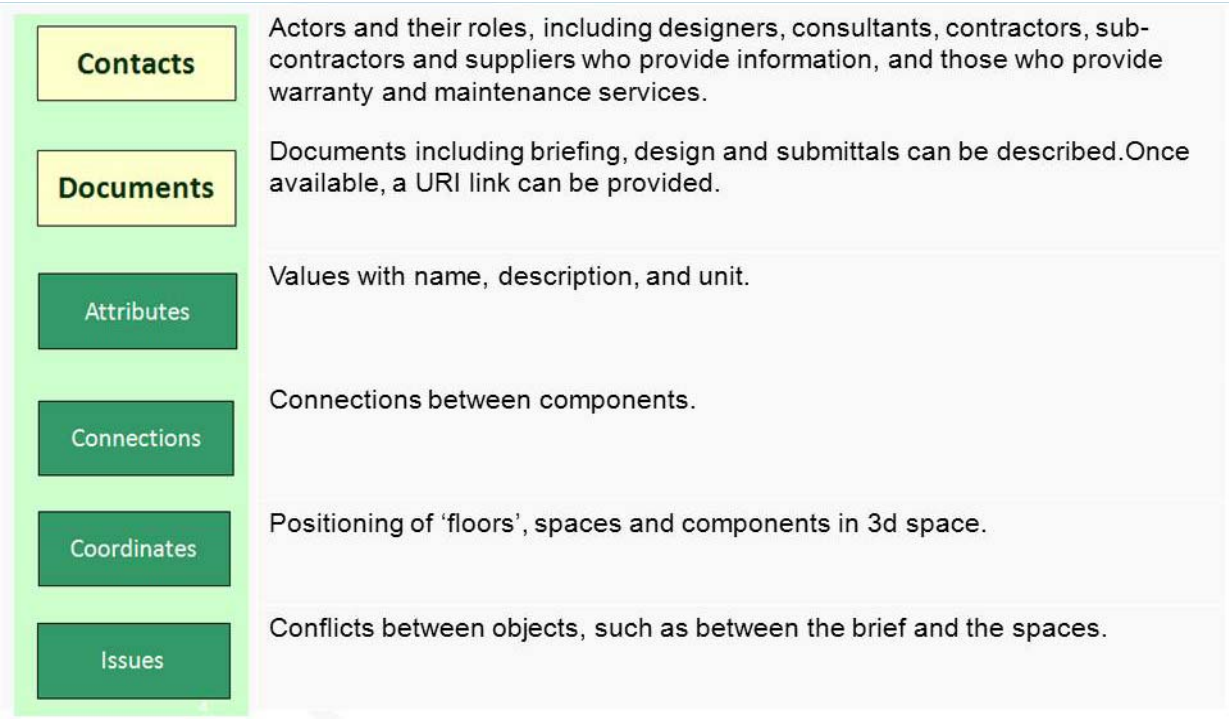
Conclusion 4: Master Plan example

The master plan is at a significantly different scale to most building facilities. It represents a continuous subdivision of the site into more and more specific patches.

COBie would benefit from an additional 'Assemblies' sheet (already proposed) to allow the nesting of spatial structures such as 'Spaces' and of physical Components. This will support a generalised infrastructure hierarchy. In the meantime, a little dexterity was needed to document the spatial structure of the example master plan. Once done all the tabulated area and land use information can be captured in COBie.

Associated information

COBie allows the association of a range of supplementary information to the objects making up the structure of the facility. These are summarised here.



Associating information in COBie (AEC3)

The documentation of 'Contacts', 'Attributes' and 'Documents' and the ability to associate these to individual objects was well received. The potential use of the ability to associate simple 3D 'Coordinates' to the objects making up the facility was appreciated. The ability to document 'Connections' between 'Components' was not perceived as significant, given the few relationships that are available in existing C/I data. However the ability to track 'Issues' was significant, as this responded to the need to prepare and deliver the "H&S file".

COBie offers scope for the creation of the "digital operations and maintenance manual" which is able to hold the data ready for use either as delivered or in Computer Aided FM systems. A COBie dataset can be transformed into an OMSI (Operations and Maintenance Support Information) document or other national standards.

Conclusion 4: The descriptive power of COBie

There was some recognition that COBie can represent the information associated to a C/I facility and to its constituent objects. The role of COBie as an index to the documentation was more palatable than the role of COBie as a data set in its own right.

Classification

COBie expects that most of the objects and associated information be assigned a classification. Classification in COBie is quite independent of the spatial and physical structure. The slide illustrates the suggested use of the Uniclass tables (CPIC)

Suggested UK Classifications (AEC3)

The documentation of Contacts, Attributes and Documents and the ability to associate these to individual objects was uncontroversial. The ability to associate simple 3D coordinates to the objects making up the facility was appreciated. The ability to document 'Connections' between Components was not perceived as significant, given the few relationships that are available in existing C/I data. However the ability to track Issues was significant, as this responded to the need to prepare and deliver the "H&S file". The C/I sector is more familiar with the coding structures published in CESMM7 and the HA than the Uniclass structure, even though Uniclass incorporates most of the C/I requirements.

Conclusion 5: Classification

Classification is fully configurable within COBie: Classification in COBie is quite independent of the spatial and physical structure. A decision not to use Uniclass can be handled. However it is to be hoped that the various efforts to produce a unified structure will yield results. Both RICS and CPIC are addressing this situation. Client bodies may recognise the value of adopting national standards as a route to lowering the cost of compliance and improving comparability.

Fixed attribute names

COBie mandates a number of fixed attribute names. A full review is not in scope of this report but there may be some which may prove unfamiliar or less useful to the C/I sector. However, given the flexibility of unlimited user-defined attributes, this can be tolerated.

The building sector has been developing sets of properties with agreed names. Agreements at the international level can be supplemented by regional or national extensions. The C/I sector has not addressed this task.

Conclusion 6: Attribute names

The C/I sector in the UK could build on the work already documented in existing standards in defining attribute names.

Life cycle engineering

C/I consultants have little direct involvement in LCA and LCC assessment .However the proposed extensions to COBie to support all life cycle impacts are likely to become relevant. For example both LEED and BREAM environmental assessments assess the use of the Site area in detail for good practice in rainwater, ecology and conservation.

Conclusion 7: Impacts

The 'proposed 'Impact' sheet is not yet seen as relevant to C/I projects but BREAM-type assessments may become relevant.

Appendix 13

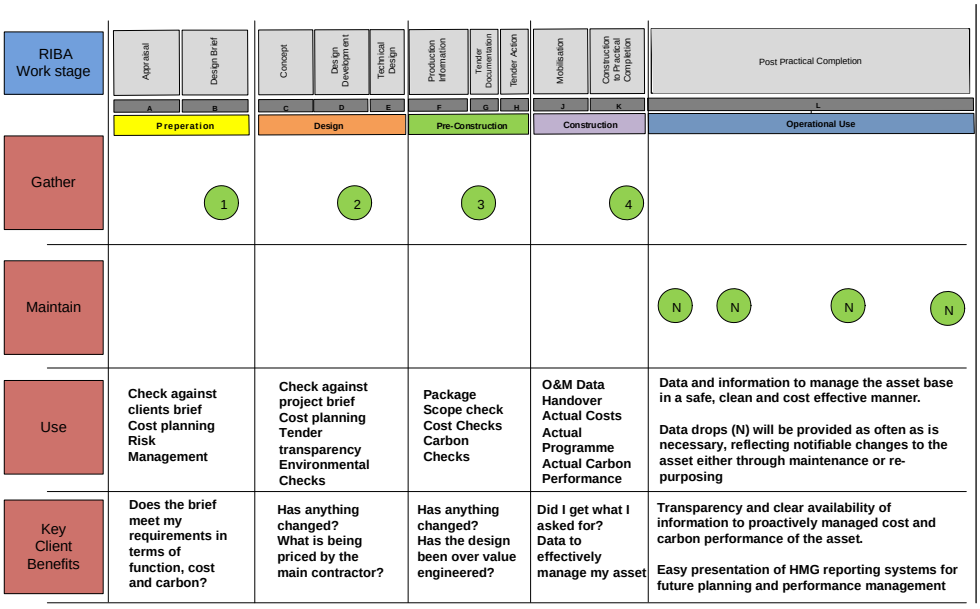
Data Management Server

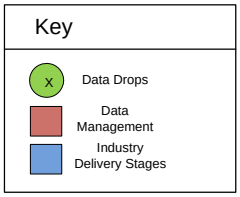
A Data Management Server is required for the express purpose of collecting and processing delivered information. It must be available 24/7, reliable, secure and intuitive to use. Its appearance and operation is to be similar to that of one of the existing "Collaboration" systems currently available in the market. Indeed it maybe that during the mobilisation period we may engage the existing service providers to enable such a service.

As we have discussed the COBie Data Standard is to be used throughout the life cycle of a project. It will be necessary for the dataset to be accessed, updated and validated by several different users from several different organisations throughout its existence in a secure and fully auditable manner.

In an ideal world, users would interact with their everyday applications and on completion of their work the COBie dataset, which could exist on several systems in a synchronised form, would be updated and validated automatically. Technologies such as Linked Data or Web Services would allow such behaviour but such an approach is currently unrealistic as it requires software vendors, whose products contribute to the dataset, to update their software accordingly. This could be several years away. In the meantime, a more practical method is required that will still ensure the integrity and security of the dataset.

The COBie dataset currently exists in an Excel format. There are several software products and several "Software as a Service" (SAAS) providers that are capable of hosting the COBie files and ensuring that it is sent (issued) to the right parties at the right time in a secure and fully auditable manner. It is envisaged that such a service will be used to control the flow and validation of the COBie dataset throughout its life cycle. The diagram (below) shows the flow of the dataset and illustrates the "file drops" that will be provided to the Client at the appropriate milestones.





Phase 1 COBie File Collection and Control

How would the process work?

Step 1

For existing builds, a COBie file (including Carbon Data) may already exist in which case this would be fed to the Design team for immediate use within BIM design tools. On new build projects, the first instance of the COBie file will probably be generated by design tools such as Revit or Micro station (although this work could be gathered directly into an XLS spreadsheet). On completion of the Concept Design process, the COBie dataset will be uploaded to the Data Management Server (COBie Control Server) for distribution and validation. Once validated, the dataset will be issued to the Client as "Data Drop 1".

Step 2

On completion of the Detailed Design process, the COBie dataset will be uploaded to the Data Management Server (COBie Control Server) for distribution and validation. Once validated, the dataset will be issued to the Client as "Data Drop 2".

Step 3

The Client (or their representative) would issue the COBie dataset together with all of the normal documentation that is required for the Tender process to those suppliers (Main Contractors) that have been invited to Tender. The Tender team (via the COBie Control server) will manage the tender process (using the Data Management Server). It is envisaged that each Supplier that responds to the Tender will update their COBie dataset and upload this back to the COBie control area for validation.

The Client will receive a third file drop of the COBie file which will be a copy of that updated by the successful supplier. This dataset will be used during the Construction phase by the main contractor. The main contractor may choose to take a copy out of the system and update it elsewhere in collaboration with his Supply Chain or invite his supply chain to use the Client's COBie Control Server to publish updates and for validation purposes. This will enable to client to view detailed information provided by sub-contractors and to ensure the employers requirements haven't been compromised during the "value engineering" phase.

Step 4

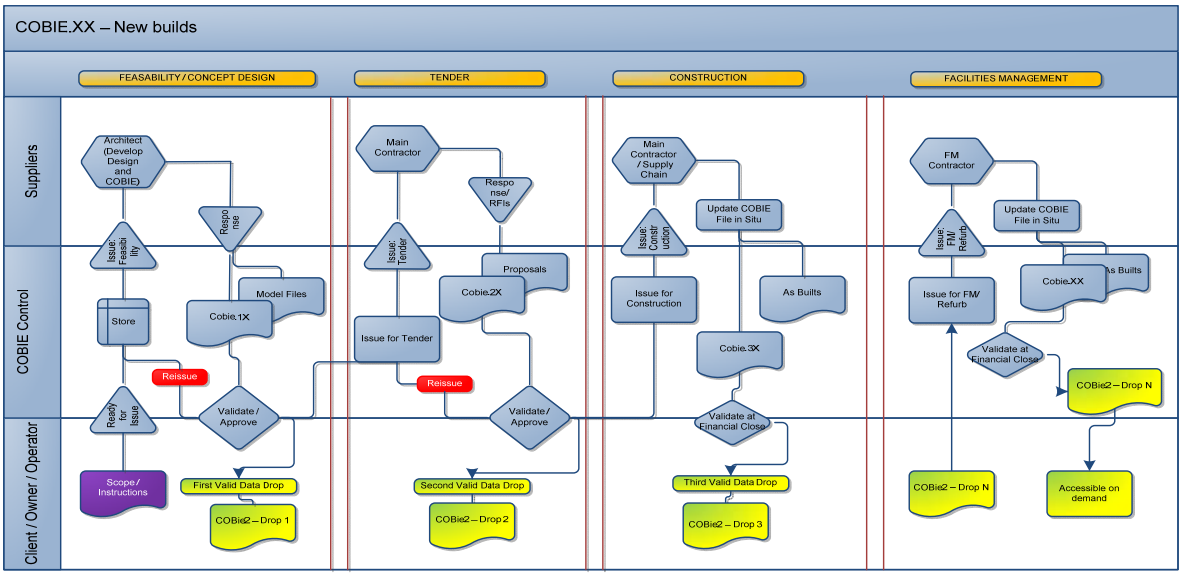
On completion of the Construction phase, "Drop 4" the main Contractor will upload the final COBie file to the Clients' COBie Control system for validation. On successful validation, the Client will receive their fourth data drop of the COBie dataset. This will represent all of the O&M information required for the long term operation of the site (coordianting and indexing all as built drawings, product data and other relevant information required at Project/Financial Close).

Step N

The Client may issue (make available) the COBie dataset to the FM contractor for continuous use. The Client will agree when to receive regular data dumps or will be given live access to the COBie file that is being used on a daily basis by the FM contractor.

Although the process diagram below is primarily focused on the flow and control of the COBie dataset, the COBie Control system will be capable of managing all project related documentation and drawings that are created and require close control throughout the duration of the project.

The system will ensure that there a single source of the truth and there are no barriers in place with regards to collaborative working – be this simply between the Client and Main Contractor or between the Client, Main Contractor and the Main Contractor's supply chain. The system will ensure that it uses BS 1192: 2007 recommend processes and terminology. This system with further ensure the continuity and consistency of the additional documentation supplied with the COBie dataset (eg Drawings, specs and other supporting documents)



Simple use of COBie in new build and refurbishment

COBie Processing and Validation

At each step the upload, validation and distribution will be managed by the system and tracked in an immutable audit trail. Only those users that have been invited to access the Dataset will have visibility of it.

Information Processing

Validation of the COBie dataset can be advanced from basic prerequisites to high quality control and completeness of verification.

Requirements for validation and checking the COBie dataset include:

(a) a valid spreadsheet or IFC file format
   a. not a document format
   b. not corrupted
   c. Correct Meta data
(b) valid against the COBie/IFC schema
   a. all references point to valid entries
   b. all restricted fields have compliant data
   c. no inappropriate use of n/a
   d. all mandatory fields are provided
   e. all names are unique
(c) all tables are developing with some proportionality

a. reasonable ratio of Floors and Zones to Spaces
b. reasonable ratio of Types and Systems to Components

(d) appropriate attributes and classification
a. match IFC specification (refer BuildingSMART documentation)
b. match UK best practice. (refer to Uniclass documentation)

(e) all change from previous version are incremental and acceptable
a. no loss of entries
b. comparison report acceptable

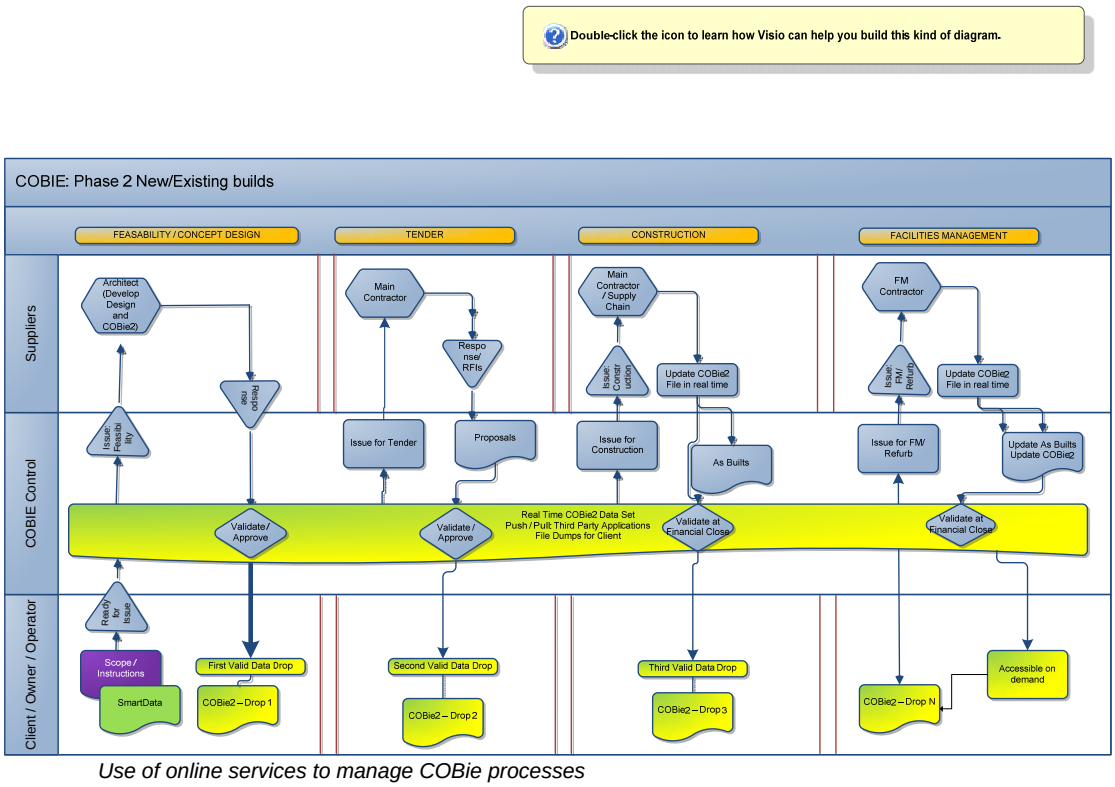
(f) examples of client defined requirements for sufficient data:
a. to analyse and report cost, value and carbon
b. to be compared with benchmarks
c. to contribute to benchmark resources
d. to populate specific CAFM applications

To date, validations (a) to (e) have been applied for US practice.

Phase 2 Real time push/pull updates: IFC / Web Services

The process proposed in Phase 1 requires several manual file uploads, file drops and file validations. The COBie file itself will be imported and exported from various applications during its lifetime. This will require significant care and attention.

It is possible for the COBie dataset to reside permanently within the COBie control environment (in a database for example) and for applications to push and pull the relevant data to it at the appropriate time (e.g. using Web Services). This will require Application vendors to update their software to i) understand the dataset and ii) allow the appropriate data to be pushed and/or pulled over Internet protocols in a secure manner. The diagram below describes this in more detail. Access, security and integrity will need to be considered carefully under such a model. This approach will also allow us to take the opportunity of appending "enhanced" data sets to the COBie data drop. This would include drawings, models, specs and calculation type information.



Use of online services to manage COBie processes

Ownership of Data

It is anticipated that the COBie dataset will be owned by the Client at all times. Ownership of all other data, drawings and documents will be agreed within the body of the contract documents.

Service Provision

There are a number of potential solutions that could be considered for the provision of this service. We do however have to remain alert to the factors and tests of both our hypothesis and the UK / European legal framework.

Potential solutions could include:

- The COBie control server is likely to be hosted and fully managed in the cloud. This will satisfy the security, disaster recovery and high availability requirements of such projects.
- It is possible for the server to be hosted on Premise (e.g. at the Clients or Main Contractor's offices/data centres). This may be required for projects that have an elevated level of security.
- Publication of a standard and service specification that could be embodied in existing collaboration service provider's offerings on behalf of HM Government.

Planning Portal Interface

We briefly explored the opportunities available for the use of the existing Planning Portal service and while there are certain appealing opportunities here, we agreed that a number of factors would need better understanding before this would be a viable option. These included:

- Better visibility of the Planning Portals business model and funding options
- The issues around information access to all stakeholders and the ability of some of these stakeholders to make use of more advanced information that was already held on the portal

With this in mind we agreed to maintain a parallel track and take any opportunity to provide links and/or portlets to the Planning Portal (and vice versa) where it is deemed to add value to the project.

Appendix 14

Communications & Institutional Support

Terry Boniface

Communications Strategy

At the outset of the project a stakeholder communication plan was created. This was to ensure consistent and cohesive communication to the interest groups who will be required to successfully enable both the Industry Push, and Government Client Pull activities, and engage in the successful transition to BIM enabled processes. A key element of the future progress of the working group and subsequent activity will be to ensure that any process devised, or restructuring of supply chains to meet clients BIM expectations, is inclusive and supported by the key opinion formers within the sector.

In reality there are, and have for some time, been numerous groups within the Industry examining the potential for BIM working. This is often in reaction to demands for information coming from within their own members and representatives reflecting the growing demand for BIM from clients, other constituent parts of the supply chain or simply a real desire to find alternate process or practices which may assist productivity and competitiveness.

However each of these groups has tended to examine BIM from their own perspective, usually independent from each other parts of the supply chain or outside of their membership groups. While there is significant BIM competence to be found in individual companies in the sector, this fragmentation of approach has meant to date been little by way of a cohesive response from the sector, able to give procurers any degree of certainty that BIM, if requested, can be delivered.

The stakeholder communications plan therefore also sought to develop a wider support for the emerging findings of the group, aiming to:

- Effectively promote of the Working Group and positively raise the profile of its members support for Building Information Modelling.
- Promote a proper understanding of the aims of the group and non-threatening nature of the activities taking place.
- Encourage wider buy-in and support for the aims and objectives of the working group and ensure other groups examining this issue contribute positively to its successful outcome
- Help us to understanding of stakeholder issues which may impede the successful implementation of the BIM group programme.
- Develop thinking on structures to take forward, where appropriate, aspects of the Groups final report.

Meetings have been held with a number of key stakeholders. These include relevant professional Institutions (RIBA, ICE, IStructE, RICS, CIOB, CIBSE, wider trade associations and collective representative bodies groups examining BIM and Interoperability, or able to influence industry perceptions of BIM (Constructing Excellence, The UK Contractors Group, the Construction Industry Council, the Modern Built Environment KTN and Building Smart), and key Government Departments and arms length bodies, either in respect of their role as key construction procurers (MoD, PfS and MoJ) or in their role as key regulators and enablers for the sector (The Cabinet Office, CLG, the Planning Portal, BSI).

A website was established for the working group to provide linkage to the other BIM interest groups and to carry and promote agreed project outputs.

Press and Publicity

Paul Morrell announced the formation of the Government Industry working Group at the Autodesk Conference in September 2010. The announcement received significant coverage within the trades press, and articles appeared in Building Magazine, BD On-line, ACE Magazine and Construction Manager. Building Magazine ran a subsequent feature on BIM, and Paul Morrell's announcement of the group, in October 2010.

Reaction to this press activity has been generally favourable, although there has been some concerns raised by the prospect for smaller companies to engage with the process.

Further publicity was given to the potential use of BIM on the Government estate by the November 2010 publication of the Low Carbon Construction Innovation and Growth Team report and its key recommendation that BIM be mandated on all Government projects over the value of £50m.

Reaction

The Construction Industry Council, Constructing Excellence and the UK Contractors Group have all been willing to give their support to the BIM ambitions outlined by this strategy. All three organisations have indicated that they would be willing to refocus their BIM messages and activities to support the Government Construction Clients Group initiative.

Constructing Excellence (with their key interest in supply chain integration) and the Knowledge Transfer Network (with a key interest to encourage innovation in the sector) have both indicated that they would use their website and industry membership to undertake wider consultation on the key element of the BIM implementation strategy.

While there remain some concerns within some of the Professional Institutions regarding the potential impact BIM may have on individual parts of the sector, initial meetings in autumn 2010 did identify almost unanimous support for both the working group and the development of a workable and acceptable methodology for BIM introduction by major procurers.

Engagement with Government Procurers has however shown some critical misunderstandings of BIM and the approach envisaged. While this is a process of education it is clear that there are significant skills and experience of BIM working within larger UK contractors currently engaged in Government Procured construction, which is not being accessed or exploited by Government clients. Skills and IT systems are identified as a common barrier to implementation however in deeper discussion, on a low level interpretation of BIM; some Government clients are already imposing information requirements on the construction supply chain which could from a good basis for BIM enablement.

Professional Institutions

The major institutions have significant influence over their membership through professional standards, research and development and education and they are a major conduit of communication to the sector.

Following the publication of the IGT, we contacted the CIC to ask whether the working group could assist in the development of the industry response to the IGT BIM recommendations. The CIC agreed this approach and agreed a CIC members meeting be convened on the 24th February to explore the professional Institutes reaction to Government Working Groups BIM proposals.

In advance of the workshop, Matthew Bacon, on behalf of the group held a number of key consultation meetings and found a convergence of approach amongst the member institutions, with regards to both BIM and Carbon reduction.

Currently there is no collective understanding amongst the Professional Institutions of BIM, its likely impacts and thee process changes required for the adoption of BIM working practices. There is a need for elucidation in this area, and Government adoption of clearer information requirements is seen as potentially, acting as a catalyst for joint action.

The Institutions recognise BIM as potentially a significant enabler of change. Consultation has identified some emergent challenges for the professions:

- **Education**. Are the programmes they currently accredit able to meet future low carbon and BIM demands? Are they producing Graduates with appropriate knowledge and understanding, and Post-graduate specialists able to take leadership roles in the sector?
- **Dissemination of best practice and new knowledge.** How can they ensure better breadth and depth of expertise, given the substantial differences in resources available between larger and smaller businesses in the sector?
- **Research and development response** How can they achieve stronger engagement between businesses and educational institutions? How can they effectively share resources across professional disciplines to leverage research funds for collective benefit?
- **Legal**. How do they overcome perceived complexities of contractual accountability, when BIM is designed to integrate data? What legal framework is needed so accountability/responsibility is managed, without becoming a barrier to implementation?

The workshop discussed the convergence between the Carbon Reduction Commitment and use of BIM. A well implemented BIM strategy could well become the means by which step changes in building design, construction and operation could bee achieved leading to radical improvement in Carbon Performance.

The issues captured at the workshop include a number of key issues of consensus, perceived barriers and agreements to future action.

The Professional Institutions clearly indicated that they would be willing to consider developing groups and collaborative processes to help develop a common understanding of BIM, consider issues of concern, and thereby give some surety to Government Clients that the industry would be willing to improve the sectors collective response to the challenge of BIM.

Recommendations

Should the Government Clients Group wish to take forward the BIM recommendation there are a number of key communication activities which will need to be considered:

- The GCCG should consider a press release to the trades press outlining their commitment to future BIM adoption. Such strong signals to the market will be key to enabling future industry BIM capability and act as a catalyst for action by the Professional Institutions.
- Future communication with existing Contractors of Supply Chain members by Government procurers will need to be framed in the context of the levels approach established elsewhere in this document.
- Framework contractors and supply chain members should, in return be asked to explain and plot their current and anticipated BIM capabilities in a similar fashion.

- A central information source should be created - either enhanced from existing websites or created - to ensure there is a platform for Government clients to share experience and trial activities on the use of BIM on the Government estate.
- This resource should also be accessible to the industry to be able to see how Government is approaching the BIM challenge including development of Government contractual conditions and contract enhancements.
- Government should maintain engagement, and encourage, key Industry representative bodies and professional Institutions to ensure those bodies continue to promote BIM to their members in a manner not detrimental to Government/ Industries BIM ambitions.

Although the leading edge of the industry, is currently considered to be able to deliver BIM at least at levels 1 or 2 we need to recognise that we need to encourage the wider industry, including SME's who may form important parts of the supply chain in their BIM ambitions. We also need to ensure that our educational systems support the development of individuals able to best meet the longer term aim for the use of (level 3), fully interoperable BIM systems.

- We should therefore retain closely aligned to future efforts of the professional Institutions in developing processes to encourage BIM capability as well as encouraging future skills development. This may include future discussion regarding the best use of current Government funding for the Higher Educational Institutes.

Appendix 15

Investment

As we have stated the magnitude of the business change requires that we deliver this programme in a very clear and professional manner. Clearly scope and rollout plans will need to be developed during the mobilisation phase, but for the purpose of illustration we have prepared an indicative cost plan for discussion.

Funding models have been discussed and there is a level of interest in the vendor market that may be encouraged into investing dependent upon the level of commitment H M Government can make to the Strategy. Some elements of the service are seen as potential revenue streams.

Description	Mobilisation	1	2	3	4	5	Notes
Documentation	£100,000	£50,000	£50,000				
Project Management	£300,000	£150,000	£150,000	£150,000	£150,000	£150,000	
Procurement Management	£100,000	£50,000	£50,000				
Communication	£50,000	£50,000	£50,000	£50,000	£50,000		
Training Management	£100,000	£50,000	-£50,000	-£50,000	-£50,000	-£50,000	
Intellectual Property & Collateral	£50,000						
Push Packaging	£20,000						
Standards Management	£50,000	£50,000	£50,000				
Membership Management	£100,000	£50,000	£50,000	£50,000	£50,000	£50,000	
Events	£20,000	£0	-£20,000	-£20,000	-£20,000	-£20,000	
Regional Networks	£50,000	£50,000	£50,000	£50,000	£50,000	£50,000	
Information Portal	£300,000	£300,000	£500,000				
Content Libraries	£200,000	£50,000	£50,000				
Total	£1,440,000	£850,000	£930,000	£230,000	£230,000	£180,000	£3,860,000

Appendix 16

Programme

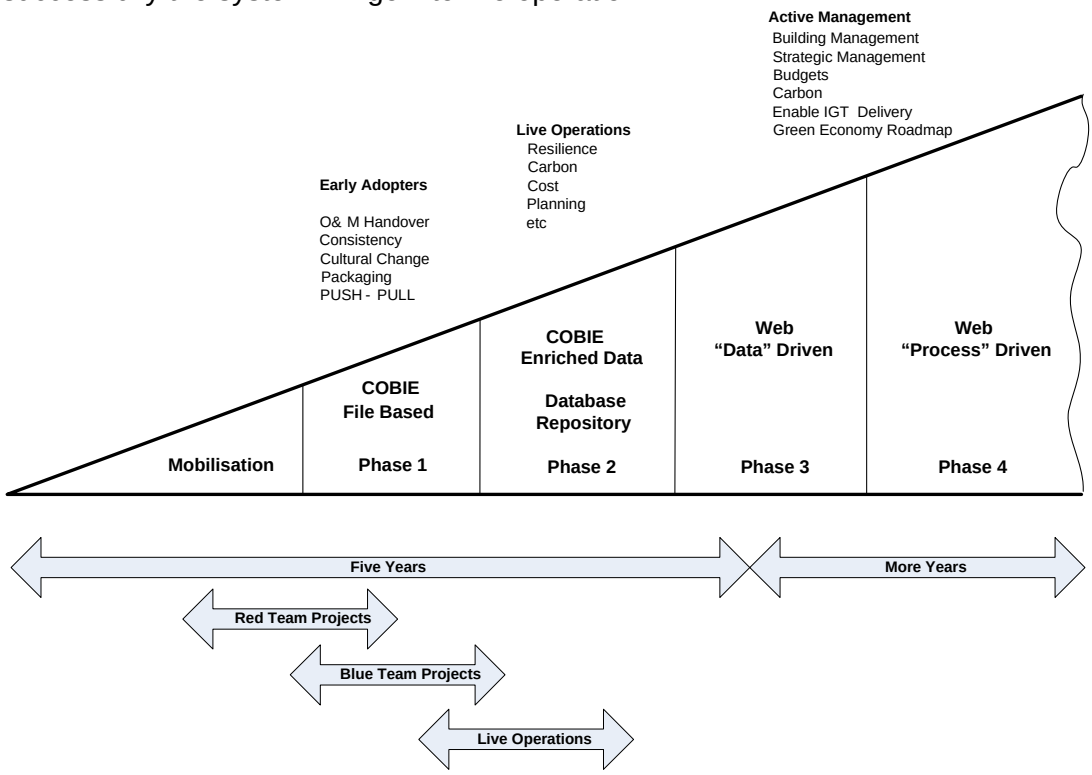
A realistic programme for an industry change programme such as this is critical to sustain delivery over the five year period. We have set as a target of all suppliers of construction services to HMG) to have reached the ability to deliver information of at least that of Level 2 in the maturity model described above. This applies to all included suppliers and lays out the five year programme to reach compliance. Our approach has been to support the trailing edge of the supply chain "pack", but being keenly aware that we should allow the leading edge to compete on an effective open basis both on the supply and client side.

There are five identified stages of the programme which are detailed in the illustration below. We have been careful to maintain the progressive approach and have taken two very small steps at the beginning of the programme to get the programme underway.

The mobilisation phase will allow time for detailed planning and delivery of the support, communications, training and technology programme.

Step one will be to start using the new process documents and contracts to deliver COBie data drops using a basic but secure collaboration style service. Step two will expand on this by extending the COBie data set to include "attached" or "enhanced" data sets including proprietary models, drawings and specifications. This will be held in a more robust database solution with enhanced management capabilities.

Step three and four are future capabilities that make use of the work underway with BuildingSMART making use of open data and process definitions. This will enable the Level 3 capabilities described in Appendix 3. The project will be delivered through a number early of adopter projects, lead as Red or Blue teams shown on the model below. It is anticipated that single procurement functions or public asset operators will set up their own "colour" teams to launch the programme with support from the steering group, support business and the supply chain as appropriate. Once the early adopter projects have passed their "go-no-go" reviews successfully the system will go into live operation.



Appendix 17

Value Proposition for BIM approach reviewed by Stakeholder

Introduction

The benefits of supply-chain integration in the construction sector are largely understood in terms of performance improvement, greater project 'certainty' and reduced risk. One of the key factors in achieving successful integration is the accuracy, effective flow and intelligent use of information which BIM – by requiring interoperability of information will encourage, although this is difficult to measure with precision. A major value of BIM will be in the post-construction phase through the on-going management of assets for optimum value in space utilisation, running costs, whole life costs and energy/carbon reduction. BIM enables design and configuration options to be quickly and cheaply interrogated against performance requirements in order to reduce cost and increase the certainty of project outcomes. This is likely to be increasingly important, if not critical, as a design tool in relation to the energy efficiency requirements being placed on assets.

Benefits to the Industry as a whole

In the US NIBS study analysts reviewed the performance of projects in the context of information management, its flows and reuse between businesses and the costs of not enabling these processes through the use of tools such as BIM. Their analysis indicated that the net-savings (offsetting set up costs) to be 5% on the construction of new-build projects and 1.5% in refurbishments. The study did not go on to analyse the savings derived from the use of BIM in operational or facilities management during the post occupancy stages.

A report commissioned by BIS in 2008 to look at the benefits of BIM, extrapolating from US derived figures, suggested that the net benefit of BIM to the UK, if extended to all major projects, would account for between £1- 2.5bn pa in the construction phase, again there was little data available or post occupancy.

Similar findings we documented in the "Investors Report" published by the BSi in 2010, a copy of which is shown in Appendix 17.

Industry reports such as the McGraw-Hill US and European BIM and Green BIM documents have been qualitative survey reports and as such represent a context and direction of thought but in themselves don't identify quantitative analysis.

Methods of Measure

One of the key strategic developments we need to establish is a consistent method of measure for the performance improvement in delivery, especially with respect to cost, whole life cost and carbon. The examples above have been gathered (with the exception of the McGraw-Hill documents from documented measurement processes. This has allowed us to draw consistent improvement conclusions across the sample base. This approach should be continued to establish and develop a continuous improvement process and culture.

Appendix 18

BSi Investors Report

Investors Report

Building Information Modelling (BIM)

Building Information Modelling enters mainstream UK construction market

Building Information Modelling (BIM) is poised to become a key means to deliver increased productivity and reduced risk within the construction sector. A number of major players have declared their intention to commence the roll-out of BIM technologies across their major project portfolios. This move will increasingly encourage successive supply-chain organisations and professionals to develop their own capability to work with the technology in order to maintain their market position or gain further competitive advantage. Serial construction clients are also beginning to awaken to BIM as a powerful post-occupancy management tool and this facility within BIM is also likely to drive demand. BIM is a major enabler for greater productivity, risk management, improved margins and sustainability as the construction sector focuses on a low-carbon future.

The Problem: Productivity in the UK market

With the tightening of the market, both in the public and the private sector, we can expect to see greater competition from the supply base, matched by a desire among clients for better value. This position will extend far beyond the short term, and every opportunity is being reviewed to find ways that will optimise productivity and efficiency.

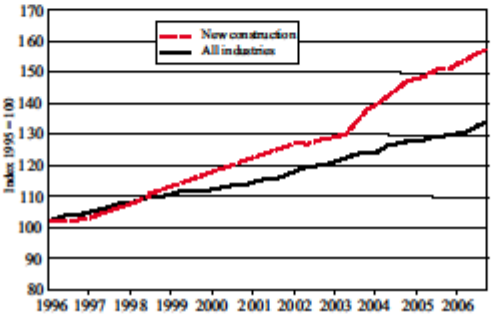


Figure 1 UK output price index (BERR Construction Statistics 2007)

When the UK and US construction markets are compared with other industry sectors, using indices of productivity (figs 1 and 2), it is apparent that construction has failed to maintain parity with these sectors – and the divergence is increasing year on year.

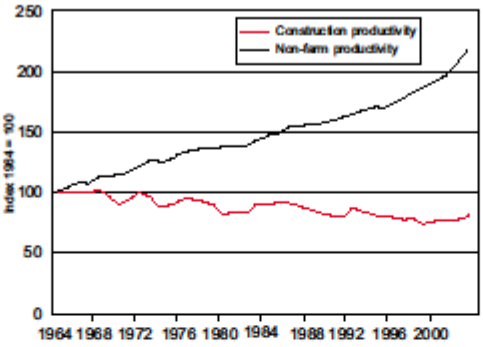


Figure 2 US construction and non-farm productivity index (U.S. Bureau of Labor Statistics 2007)

There is no single cause for this. But if we look at the retail, automotive, electronics and aerospace industries, transformation in these sectors could have only come about through the adoption and continuous development of modern processes and technology. If you take, for example, the data-rich retail market, accurate information is routinely used to predict and improve responses to client requirements. The construction industry, by contrast, captures and retains little data about the assets it delivers and operates. What data the sector does capture is rarely sufficiently analysed to allow performance on the existing project – or delivery of the next – to be improved. Building Information Modelling seeks to bring to construction and the built environment a mechanism and an opportunity to achieve sustained transformation. Early adopters are beginning to deliver tangible benefits to themselves and their clients and have demonstrated that BIM is a powerful tool to reverse the productivity trend.

Lean, green and clean

The market continues to respond to the green agenda in all its forms, but current processes are almost always carried out in isolation. The built environment is one of the nation's largest polluters after transport and power generation, and an integrated approach using BIM data will ensure that assets can be delivered and maintained in the cleanest, leanest way possible.

BIS Produced with support from the Department for Business Innovation & Skills

BIM... At a glance

Key Benefits
- Early cost certainty
- Reduced delivery costs
- Reduced operational costs
- Green performance
- Reduced risk
- Predictable planning

Key Projects
- Palace Exchange, Enfield
- Festival Place, Basingstoke
- Endeavour House, Stansted
- Terminal 5, Heathrow
- Portcullis House, London
- St. Bart's Hospital, London

Early Adopters
- Scott Wilson Group
- BDP
- BAA
- Laing O'Rourke
- Skanska
- Arup
- HOK

References
- BS 1192:2007
- Avanti BIM Guide
- The Business Value of BIM – McGraw-Hill, 2009
- Low Carbon Construction – BIS, March 2010
- Strategy for Sustainable Construction – BIS, Sept 2009

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- BSI committee B/555: Peter Rebbeck (rebbus@btopenworld.com)
- CPIC: Mervyn Richards (mervyn.richards1@ntlworld.com)

Acknowledgements
Mark Bew*, Scott Wilson Group; Mervyn Richards*, MR1 Consulting; Jason Underwood, University of Salford; Barry Blackwell, BIS

* Member of the BSI Committee B/555, Construction Design, Modelling and Data Exchange

More about BIM – Free download
- Constructing the Business Case: Building Information Modelling

http://shop.bsigroup.com/bim

Appendix 19

Building Information Modelling and Management (BIM(M))

Interim Report from the BIS/Industry Working Group – September 2010

1. Purpose

1. The purpose of this document is to brief the Construction Clients Board of the progress made by a working group established by BIS looking at the construction and post-occupancy benefits of BIM(M) (Building Information Modelling & Management) and the intention to develop a structured Government/sector strategy to increase BIM(M) take-up over a five year horizon.

2. Recommendations

1) The Board are asked to endorse progress to date with this work and note the opportunities BIM(M) creates to improve supply chain performance and operational performance to UK built assets
2) To invite the Board to bring the working group under its auspices and agree to receive its final report in March, 2011
3) To invite participation in the working group from individual departments and other bodies
4) To identify suitable projects on which BIM(M) practice can be demonstrated to the Construction Client Board
5) The Board agree a copy of this paper be sent to John Suffolk, The Government Chief Information Officer, inviting views on any impact this work may have on the current review of re-engineering the Government Procurement model.

3. Aims and Objectives of the working group.

The working group was set up in the spring of 2010 and is supported jointly by Construction Sector Unit and Electronic and IT Services Unit at BIS. The working group draws in representatives from the construction sector, its client-base and software suppliers (identified in Appendix 1 and work programme leads in Appendix 2) and aims to report on:

A) How measurable benefits could be brought to the construction and post-occupancy management of structures (buildings and infrastructure) by increased use of BIM(M) approaches.

B) What more clients would need to encourage the widespread adoption off BIM(M) approaches to improve project delivery and operational performance.

C) To review international mechanisms and, in particular, the US Federal Government's five year programme which have encourage BIM(M) adoption elsewhere and to make recommendations on their lessons for the UK over a similar time horizon.

D) The potential of Government policy on BIM(M) to assist the UK consultancy and contractor base to maintain and further develop their currently strong standing in international markets.

SUPPORTING INFORMATION

4. What is BIM(M)?

BIM(M) is a managed approach to the collection and exploitation of information across a project. At its heart is a computer-generated model containing all graphical and tabular information about the design, construction and operation of the asset.

BIM(M) allows design options to be explored digitally. Design changes are quicker and cheaper to enact when compared to traditional design tools. It is the technological and process successor to CAD and 2/3D drawings and creates data files or 'objects' of physical components and spaces to produce a sophisticated 3D graphical model of the asset and all of its associated information. The levels of sophistication or 'maturity' of BIM(M) usage are shown in Appendix 3.

The data generated contain information on detailed dimensions, component-placement, material specifications, structural performance, fire rating, "U" values, and carbon content (both embedded and operational), cost, maintenance schedules and performance etc. In effect, the structure is built 'virtually' using these exact data-rich objects from which plans and drawings can be generated. It is a distinguishing feature of BIM(M) that no traditional 'drawings' are involved in the creation of the model and the data in the model - which is not present in static representations of the structure - can be analysed and selectively made available to meet demands and function across the whole life cycle of the structure. Drawings are a reporting output of the process, not the inherent process itself (although the model will supersede 'drawing' over time). The BIM(M) model provides clear accessible information which can then be exploited and used to manage the construction and management of structures which – if exploited correctly – can lead to significant efficiencies and improved delivery of client 'value' in construction and, in particular, cost saving.

The process of delivery and operating assets is complex and expensive with a generally high level of perceived risk. Many initiatives and studies including Latham, Egan and more recently Wolstenholme have identified efficient collaboration, widespread use of technology (including ICT as an enabler of integration), offsite manufacturing and lean techniques as key drivers for reducing excessive waste and poor performance. Sectors such as retail have demonstrated that the effective capture and re-use of information delivers dramatic improvement in the development and prime utilisation of assets.

Benefits of BIM(M)

The benefits of supply-chain integration in the construction sector are largely understood in terms of performance improvement, greater project 'certainty' and reduced risk. One of the key factors in achieving successful integration is the accuracy, effective flow and intelligent use of information which BIM(M) – by requiring interoperability of information – will encourage, although this is difficult to measure with precision. A major value of BIM(M) will be in the post-construction phase through the on-going management of assets for optimum value in space utilisation, running costs and energy/carbon reduction. BIMM enables design and configuration options to be quickly and cheaply interrogated against performance requirements in order to reduce cost and increase the certainty of project outcomes. This is likely to be increasingly important, if not critical, as a design tool in relation to the energy efficiency requirements being placed on buildings.

Globally, there have been a number of cases studies, research programmes and consultancy projects to assess the benefits of BIM(M). These suggest that BIMM can provide significant financial benefits and, on the strength of this work, a number of countries have developed specific initiatives to support its adoption and occasionally mandate its use.

A report commissioned by BIS in 2008, extrapolating from US derived figures, suggested that the net benefit of BIM(M) to the UK, if extended to all major projects, would account for between £1-2.5bn pa in the construction phase. The original US study indicated that the net-savings (offsetting set up costs) to be 5% on the construction of new-build projects and 1.5% in refurbishments. The study did not go on to analyse the savings derived from the use of BIM(M) in operational or facilities management. The ROI for BIM(M) systems is estimated as being 'greater than 60%' based on a survey of users by one of the major vendors.

Figure 1 shows the benefits of BIM(M) based on published UK commercial data. The 'as measured' benefits can be attributed to the various stages of construction based on the RIBA stages. The evidence is that there is a consistent reduction of 8-10 % of costs associated with 'construction' (stages F – K). Although, the other indicators are all positive, the profile of the curve very much reflects the current experience and main usage of BIM(M) which is in the design/pre-construction stages. The prediction is that operational savings in FM management and the integration of BIM(M) with environmental systems is likely to be a major focus for cost saving.

The main asset of BIM(M) is not the software but rather the information and its accessibility, with controls, to the whole supply chain. Clients benefit from these process improvements and from greater transparency and certainty of information (and specifically cost information).

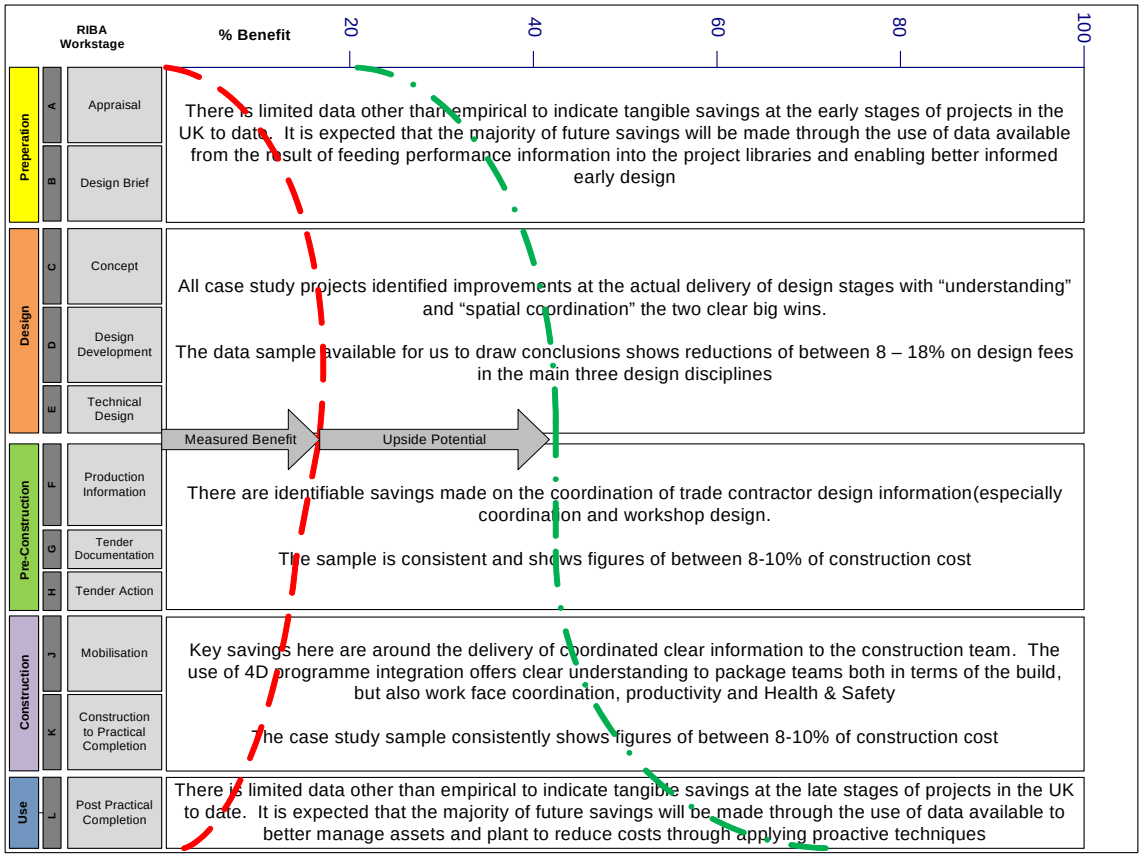


Figure 1: Benefits of BIM(M) against RIBA Stages (left – currently 'as measured' right – estimate of 'potential' benefits)

International Experience

In Finland, *Senate*, the property services agency carried out a number of pilots using BIM(M) from 2001 to develop the use of product models. Based on its successful experience, in October 2007 it required the use of IFC BIM(M) models on all its projects. Norway uses an IFC BIM platform for automated code checking and its *Directorate for Public Property and Construction Management* uses IFC BIM to facilitate the flow of information through the whole life-cycle. *The Norwegian Defence Estates Agency* ran three BIM(M) pilots (2007-2009) and mandated BIM(M) in 2010. In Denmark there is a mandated use of 3D/BIM for design and call for tender and an electronic handover of information to the client, while the Palaces and Properties Agency, The Danish University and Property Agency and Defence Construction Service are all exploring wider BIM (M) requirements.

The US Federal Government's General Services Administration (GSA) provides and maintains Federal buildings across the USA. In 2003 they established through their Public Building Service (PSA) and the Office of the Chief Architect (OCA), a dedicated national programme for the phased introduction of BIM(M) approaches. The December 2003 Memorandum states..

'Cost *overruns and claims can be reduced on our construction contracts by improving the quality of our design product. New technology now affords us the opportunity for quantum improvements in design quality by building our buildings virtually before building them physically. Other industries have achieved major quality and productivity improvements through the use of object model technology based on open standards of interoperability. Interoperable object models technology also allows automated standards checking and cost estimation to better control project scope and cost. Beyond the expected improvements in design quality, this technology will enable full transfer of design information into construction, facility management, and operations-maintenance. The Office of Chief Architect will work with the regions to implement this new technology in our capital construction programme as soon as possible. The goal would be to provide interoperable building information models in support of all national office concept reviews on projects receiving design funding (FY 2007) and beyond. The OCA will develop an issue additional guidance, including regional pilot opportunities, to make good on this reality'.*

All major projects since 2007 have required spatial BIM(M) s as a minimum requirement and are encouraged to deploy BIM(M) to support of specific project challenges. The US Coast Guard also requires BIM(M) as do a number of US States.

None of the programmes will directly replicate to the UK situation, however, the GSA model of a structured and phased introduction of BIM(M) over a 5 year period is being closely examined and links with the GSA have been forged to improve our understanding of their methodology and to share experience.

We have also forged very close links, which we will be seeking to formalise with BSI, US Department of Defence/ Coastguard and BuildingSMART[3.] In addition we are collaborating with the Construction KTN and have in place a communication strategy we other BIM(M) groups who are looking at different aspects of the agenda.

Work Programme

The activity programme of the working group is explained in Appendix 4.

Appendix 1:

The Working Group

The working group is composed of two sub-groups focused respectively on the construction issues and software issues of BIM(M). The segregation also allows for cross-verification of emerging findings. A core stewardship grouping composing both software and construction elements has been formed to lead work programmes and are marked '*'.

Mark Bew (Director, Scott Wilson and Chair of BuildingSmart) co-chairs both groups in order to maintain continuity and to facilitate progress between groups.

The Consumer Sub-Group

Mark Bew'*'	Scott Wilson (Joint Chair)
John Lorimar'*'	Manchester City Council (Joint Chair)
Andrew Wolstenholme'*'	Balfour Beatty
Mike Underhay	Arup
Bill Price	Costain
John Roycroft	BDP
David Throssell	Skanska
Nigel Fraser'*'	BAA
John Ioannou	OGC
James Brown	Asda
Jon Wallsgrove	Architect MOJ
Simon Rawllilnson'*'	Davis Langdon
Andrew Thomas'*'	Salford Uni
Rod Mcdonald	Buro Happold
Paul Shillcock	London Underground

The Software Vendor Sub- Group

Mark Bew	Scott-Wilson (Chair)
Adam Matthews'*'	Autodesk
Steve Jolley'*'	Bentley
Andrew Bellerby'*'	Tekla
Steve Brunning	Rapid 5D Ltd
Peter Moyes	Artra
Steve Dunwel'*'l	Oracle
Nigel Tilley	Microsoft
Daniel Theo'*'	IBM
Dr Sarah Graham	IES
Simon Godfrey	SAP

Appendix 2: Current Activities & Programme

Activities

The Core Team is working on a set of seven work streams with key members of the construction and software supply chain to lead work items. This document will define the costs and benefits of delivering the hypothesis stated in this document and the methodology by which we recommend it is brought to fruition.

Current Activities

No	Activity, and Leadership Group	Comments
1	**Contracts & Legal** Simon Rawlinson Nigel Fraser John Lorrimer	Discuss with John Henderson at Beale & Co FM Institution for further support Key Issues • Copyright • IP • All Standard Contract Types • Keep Simple (don't invent new route, modify/develop existing) • View from client perspective • Collaborative working • Target cost • Ownership of data • Budget issues
2	**Delivery Standards** Nigel Fraser Steve Jolley (Phil Jackson)	Steve Jolley to publish Bentley documentation to collaboration server Review BAA, BSi, Bentley, Reading projects and establish most effective delivery mechanism, preferably with BSi publishing an appropriate document of PAS
3	**Training & Support Systems** Andrew Thomas Andrew Bellerby Adam Matthews Steve Dunwell Steve Jolley Chris Harvey	Develop an appropriate strategy to "Package" BIM tools and services to make adoption much, much simpler for the "average" supply chain player. Key Issues • Definition of packages • Assessment or accreditation • User competence • Client & Supply chain • How do we manage IPR on accreditation of we chose this route? • Discuss training material already produced by Jason Underwood at Salford
4	**COBie.XX Definition** Adam Matthews Andrew Thomas John Lorrimer Steve Jolley Michelle Barker	Develop an understanding of the COBie standard and present to next meeting. Identify "missing" elements required to achieve our hypothesis. Discuss with GSA and Nick Nesbitt Key Issues • Geometry requirements • Whole Life Costs • Carbon • Linkage to work stream 3
5	**Data Management Server** Michelle Barker Mark Bew	Identify services required to deliver a pilot service and more strategic requirements for production services. Key Issues • Explore GSA offer • Check IP issues on US services used from the UK Export Tax Issues
6	**Cost Benefit Analysis for Each Stake Holder** Chris Harvey Nigel Fraser Other vendors	Review existing material Discuss with Jason Underwood and Alan Redmond Review Post Occupancy Stages
7	**Communications, KTN and Institutions** Terry Boniface	Develop strategy to disseminate and involve where required third party stakeholders. Include GSA and other international organisations

Appendix 3: BIM (M) Maturity Levels

A maturity model has been devised to ensure clear articulation of the levels of competence expected and the supporting standards and guidance notes (not shown in this diagram), their relationship to each other and how they can be applied to projects and contracts in industry. The purpose of defining the 'level's from 0 to 3 is to categorise types of technical and collaborative working to enable a concise description and understanding of the processes, tools and techniques to be used. In essence, it is an attempt to take the ambiguity out of the term 'BIM(M)' make specifying for it clear and transparent to the supply-chain and enable the client to understand precisely what is offered by the supply-chain. The production of this maturity index recognises that differing construction client and their supply organisations are currently at different level of experience with their approaches to BIM(M) and serves as a structured 'learning' progression over a period of time.

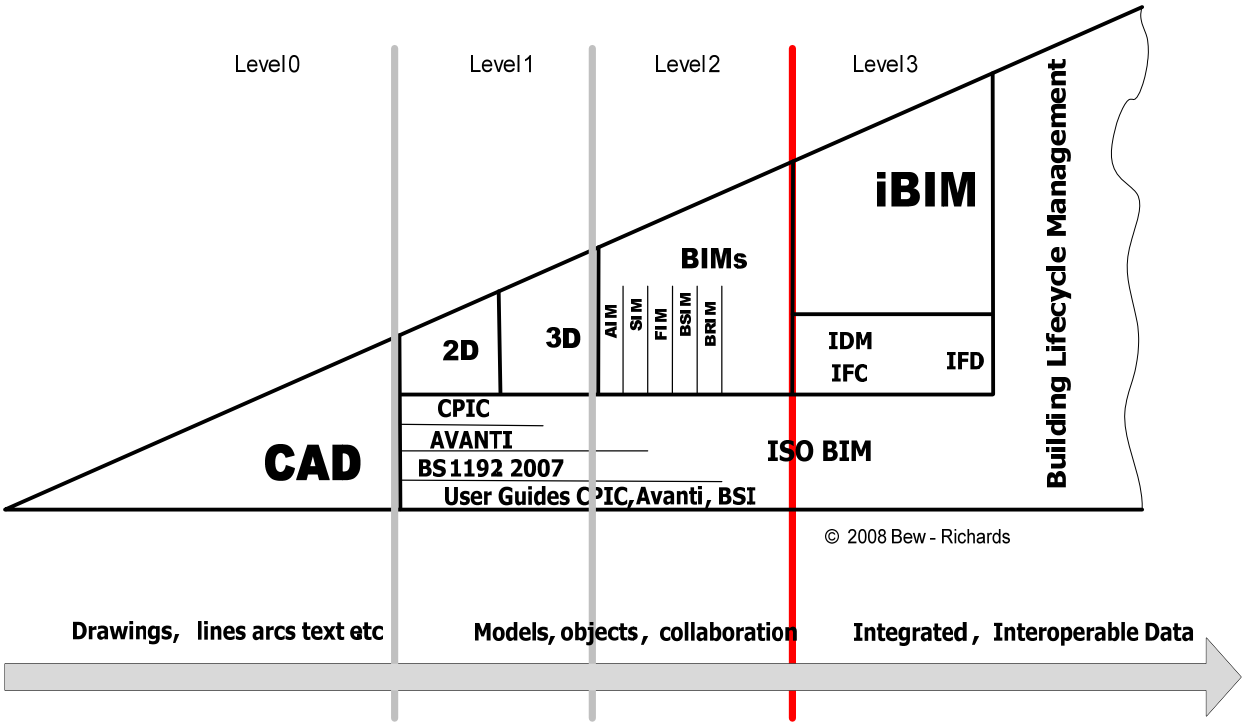
Level Definitions (supporting documents not shown)

0 Unmanaged CAD probably 2D, with paper (or electronic paper) as the most likely data exchange mechanism.

1 Managed CAD in 2 or 3D format using BS1192:2007 with a collaboration tool providing a common data environment, possibly some standard data structures and formats. Commercial data managed by standalone finance and cost management packages with no integration.

2 Managed 3D environment held in separate discipline "BIM(M)" tools with attached data. Commercial data managed by an ERP. Integration on the basis of proprietary interfaces or bespoke middleware could be regarded as "pBIM" (proprietary). The approach may utilise 4D Programme data and 5D cost elements.

3 Fully open process and data integration enabled by IFC / IFD. Managed by a collaborative model server. Could be regarded as iBIM or integrated BIM(M) potentially employing concurrent engineering processes.



Appendix 4: The work programme Approach

The Process

The working group has devised a hypothesis and number of 'tests' to guide and validate its work and to develop a strategy for the phased widespread introduction of BIM(M) with increasing maturity (appendix 2).

The Hypothesis

"Government as a client can derive significant improvements in cost, value and carbon performance through the use of open sharable asset information"

To ensure that the hypothesis can be robustly tested we identified the following tests.

- **Valuable:** The overall aim is to maximise client value by increasing benefits at little or no extra cost.
- **Understandable:** The approach is to be presented in an understandable learning package suitable for different types of government asset procurers.
- **General:** the approach is equally applicable to buildings and infrastructure, whether large and small new build and where possible existing structures.
- **Non Proprietary:** All requirements are non-proprietary as to applications and as to the required formats of the deliverables.
- **Competitive:** Wherever possible there are at least two solutions or methods available so as to minimise market influence in terms of anti competitive clauses.
- **Open:** Wherever possible, low-cost methods are to be made available to allow all stakeholders to participate, irrespective of size and experience, so as to minimise barriers to involvement.
- **Verifiable:** All contractual expectations are documented with transparent and testable measurement of pass / fail.
- **Compliant:** Measurement of WLC/Carbon/Sustainability/etc are to published GB, EU and ISO standards
- **Implementation:** The approach is self funding by the client and the industry
- **Timescale:** The approach is phased in over 5 years

Strategies

The hypothesis is by design non-prescriptive in its definition. It doesn't say 'you must use BIM(M)' for example. It does however identify exploitable 'information' as the key driver to enable improvement.

If the two key variables that matter in terms of performance are Whole Life Cost and Carbon Performance these should be the variables that are measured in HMG contracts going forward. As all asset data will be owned and retained it won't matter if in the future the key drivers change as these will simply by new calculations on existing retained data sets.

To enable the delivery of this data there are two strands to the strategies which are being pursued - which we have defined as our "Pull - Push" approach.

3. The first strategy is the supply chain "Push" element looking at the supply chain itself and methods by which we could make it easier for the supply chain to make use of technologies such as BIM(M) more easily. There are many vendors in the market all with their offerings purporting to be the best BIMM solution. All of the supply chain teams are at differing points in the maturity curve and all think that their flavour of BIM(M) is the answer to all. There is also a dearth of materials and common processes available to offer consistent advice to the processes, data definitions or deliverables specifications. Finally there are few training materials or courses delivering consistent people capability. The proposal for this strategy would be to adopt the "Maturity Levels" model described above and have "Packages" of products, standards, guides and training to support their delivery.

4. Strategy strand two looks at the client "Pull" and the possibility of specifying a set of data to be provided by the supply chain to the client at specific times through the delivery and operational life of the asset. This would rely on the careful definition of what data deliverables would be needed and when linking in to the standards and specification process above.

There are a number of attractions in this two pronged approach. In discussion with the US GSA team we have discovered a number of parallels and in our adoption of our own approach we hope we have not only "anglicised" the approach, but also have been able to avoid some of the shortcomings and pitfalls identified by the American team during the implementation of the GSA standard. We have also been kindly offered the opportunity to use the GSA infrastructure to conduct our own "Pilot" projects.

By packaging the BIM(M) products and services into "Level" products we will be able to simplify the approach for supply chain users, offering an understandable package to the market supported by the vendors, but critically without H M Government specifying any single product, but still guaranteeing a consistent delivery and performance outcome.

Further, this approach can be seen as a development of the existing OGC Gateway Process and the Planning Portal Process, both of which are already in the market and in use with the associated infrastructure and services.

Appendix 20

Draft (illustrative, for discussion)

Deliverable: Building Information Modelling and Management Protocol for project:

(Insert project name)
……

Note on the concept of this document:

For inclusion under deliverables in an NEC3 type contract in the Works Information section from the party with overall responsibility for design coordination and integration.

The client requires that an appropriately mature building information model be delivered covering the whole scope of the project for each gateway review.

Contents

1 Introduction

This is a contractual BIM Protocol for the project defining different levels of design maturity for each project phase, who will develop the content, to what standards, who will be authorised to use it, for what purpose, how it will be coordinated, how change will be managed, who will own what and how information incompatibilities shall be resolved.

2 Definitions

2.1 Building Information Modelling and Management BIM

Building Information Modelling *and Management* is digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about it forming a reliable basis for decisions during its life cycle, from earliest conception to demolition. *(based on CPIC definition)*

2.2 Design Maturity

The completeness of a design as required to successfully proceeding through an OGC Gateway Review, IE:

- 1 Business justification
- 2 Procurement strategy
- 3A Design Brief and Concept Approval
- 3B Detailed Design Approval
- 3C Investment decision
- 4 Readiness for Service
- 5 Benefits evaluation

2.3 OGC

The UK Government's Office of Government and Commerce

2.4 Project Phases

The periods of project activity that lead to a Gateway review. *(These may be based upon the RIBA Outline Plan of Works or another similar methodology)*

2.5 Model Objects

Elements of the building information model which represent components, sub-assemblies, assemblies, and systems within a building (including infrastructure) as defined in the *UNICLASS (or other)* codification system.

2.6 Model Manager

Overall model development, coordination and integration shall be the responsibility of the Model Manager.

2.7 Model Content Developer

The organisation (legal entity) responsible for developing model objects to a specified level of maturity and specified use.

2.8 Authorised User

The organisation (legal entity) that may use and rely upon the model content for specified uses.

2.9 Configuration Management

A technique used to support the control of the design, production and management of a product or facility through the identification of inter-relating objects and the management of changes to them. It is described in BS ISO 10007:2003 as guidance to achieving BS ISO 9001 compliance.

3 Model Content Development

For the following contracted phases of the project the Model Manager shall be:

Organisation	Project Phase
.....	.....
.....	.....
.....	.....

The Model Manager shall establish the operational context for developing the Model, including:

- Set up the single model environment in compliance with the Applicable Standards
- Organise secure information storage
- Define collaboration processes *(if not covered by Applicable Standards)*
- Control access to the information
- Organise model integration within the geospatial grid specified by the client
- Define interfaces between different Model Developers' deliverables and maintain them under configuration management
- *Insert other requirements (EG project specific….)*

During the period that the Model Manager is responsible for the Model it shall:

- Work to the defined processes
- Record, issue and receive model elements as required
- Ensure that model elements received are complete, clash free and conform to Applicable Standards, proactively resolving non-compliances with the relevant Model Element Developer(s)
- Archive each database and file received and back up data to a remote location (both individual model elements and the combined Model)
- Assure complete, coordinated, and integrated model elements are provided to project participants and the client to an agreed schedule
- Consolidate individual model elements into the combined Model
- Provide viewable Models as required by the client and other project team members
- *Insert other requirements (EG project specific….)*

4 Authorised users of the building information model

The following table authorises the named organisations to use and rely upon the model information for the uses indicated by the presence of a "X" at the intersections in the matrix.

Model User: *(right)* / **Specified Use** *(below)*	*Client name*	*Architect name*	*Structural Engineer name*	*Service Engineer name*	*Acoustician name*	*QS name*	*Builder name*	*etc*
Site orientation	*X*	*X*						
Visualisations	*X*	*X*						
Floor area / volume / capacity assessment	*X*	*X*						
Facilities schedule	*X*	*X*		***(to be completed)***				
Applied analysis					*X*			
Cost estimation		*X*				*X*	*X*	
Clash avoidance		*X*	*X*	*X*				
Materials content take off						*X*	*X*	
Build sequencing		*X*	*X*	*X*		*X*	*X*	
etc								
etc								

(Table content is illustrative and incomplete)

5 Authorised uses of the building information model in each project phase

Use	**Project Phases covered by this contractual appointment**						
	To OGC 1	*To OGC2*	*etc*				
	RIBA A	*RIBA B*	*etc*		*(or others)*		
Site orientation	*X*						
Visualisations	*X*						
Floor area / volume / capacity assessment	*X*						
Facilities schedule	*X*						
Applied analysis			***(To be completed)***				
Cost estimation							
Clash avoidance							
Materials content take off							
Build sequencing							
etc							
etc							

6 Model ownership

Model ownership is determined by the terms and conditions applicable to the ownership of intellectual property as agreed between the client and its contracted supplier of this information.

Provision of model information does not convey ownership of the software used to develop the Model.

7 Applicable Standards

The following standards are applicable:

National and international standards and statutes : *(insert as applicable)*

EG:

- BS 1192:2007
- BS 7000:1
- UNICLASS
- Building Regulations – Health and Safety Manuals / CDM documentation
- etc

Client's internal standards: (insert as applicable)

EG:

- CAD conventions
- Single Model Environment
- Geospatial grid
- Document and file naming
- Document and database management
- Building element coding
- Asset naming
- Standard product objects
- etc

Appendix 21

Glossary

AIA	American Institute of Architects
BIM	Building Information Modelling
BRE	Building Research Establishment
BREEAM	BRE's Environmental Assessment Methodology
CDF	Common Data Format
CIMM	TfL programme & project process for underground transport
GIS	Geographical Information System
GRIP	Network Rail project management process
IFC	Industry Foundation Classes (data formats)
LEED	Leadership in Energy and Environmental Design assessment methodology
OGC	Office of Government & Commerce
PAVA	Public Address & Voice Alarm system
Spearmint	Tfl programme & project management process for surface transport
TfL	Transport for London
UNICLASS	A coding system for building components – published by CPIC
BRE	Building Research Establishment
CO_2	Carbon Dioxide
CO_2E	Carbon Dioxide Equivalent
GHG	Green House Gases
DECC	Government Department of Environment and Climate Change
IGT	Innovation and Growth Team
IUK	Infrastructure UK
GCCB	Government Clients Construction Board
CIC	Construction Industry Council
RIBA	Royal Institution of British Architects
ICE	Institution of Civil Engineers

Appendix 22

Caveat

The key principle of the strategy is that the Construction Industry will respond to the opportunity created by government with innovation and solutions, the Government Construction Client should anticipate some inertia, should aim to encourage a single voice in the industry and be prepared to manage the outcomes of the initial development work streams.

A report commissioned by the Department of Business, Innovation and Skills
First Published July 2011
URN 11/948