CONSTRUCTION MANAGER'S BIM HANDBOOK

John Eynon

WILEY Blackwell

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Dedication

Firstly to the Tribe of Eynon – my wife Anne Marie, and my children Natalie, Michael and Robert. I'm not sure they ever quite understand what I do, or why, but they support me anyway – thank you!

Secondly, this Handbook is dedicated to all those like me, who believe that our industry can be and should be so much better – more professional, respected, diverse, innovative, technologically advanced, valued and … ..fun!

It can really happen! … .. Keep the faith!

Cheers! :o)

JOHN EYNON

#BIMCreed

Our god is in the Cloud
We have legions of Servers
We have our own Language … IFC, LOD, 1192, B555, BEP, MIDP, TIDP *et al*.
Our Icon is the Wedge, forever may it be hallowed, branded on our palms
Our Holy Writ is the 1192s and The Protocol
We have our Apostles … Mark, David and Mervyn – forever may they be venerated
Our Acolytes, Evangelists and helpers are everywhere … they are the #BIMcrews, the #BIM4s, the #BIMCommunities and #TheB1M
Collaboration is our Shield of righteousness
Interoperability is our Staff of comfort, may our BIM always be Open
COBie/IFC is our Watchword … respect to the Nick and the Smart Builders

WE are passionate, fervent
WE are enthusiastic
WE are committed to the #BIMcause
WE are the Makers … we are the Coders and Digital Engineers, the growing point of the revolution
WE conceive, create, design, make, construct and operate

WE *will* transform our industry for a better day for all –
Respected, efficient, lean and profitable, technically innovative, oozing quality and creating an outstanding environment
And having fun :o) LOL!
UKPLC will be the leading global digital information economy, and #AECOBIM will be at its heart

Go forth in the Name of the #BIM and multiply!

Contents

Foreword

Building Information Modelling and related technologies are set to transform our industry beyond recognition.

Within a generation we will have a digitally enabled industry sharing data and information via the Cloud across all stages of the asset lifecycle – seamlessly, efficiently, consistently, reliably and creating value for all stakeholders in the process, but most of all for asset owners and operators – our customers.

You may feel this is a far cry from the current state of affairs in our industry, but nevertheless this is where we are headed. Many are already on this journey, and more begin every day. A few years ago, in 2011, the UK Government embarked on a bold programme – to move our industry towards delivering digital management of assets in the public sector.

The target was set of reaching BIM Level 2 (UK) by 2016. For the leading UK Government departments this has been met, but we know the reality at local authority level and in the private sector is very different. Upskilling SMEs is a particular challenge. Our industry has a notoriously long tail and it will take several years before we can confidently say that we have reached Level 2 across the board.

However, Level 2 is but a staging post on the journey to Level 3 and beyond. The recently published Level 3 strategy document – Digital Built Britain – signposts us to the Internet of Things and the Internet of Everything, Smart Cities, Big Data and a world where everything joins up, including the built environment.

Moreover, this approach positions our industry as a leading player in the Digital Information Economy – UKPLC. The UK approach in developing the strategy, processes and standards to enable this vision to be achieved has already won international recognition – and considerable envy!

CIOB people are leading members of the industry holding responsible roles across the whole asset lifecycle. This guide for Level 2 brings together comment, guidance and advice from some of the leaders in UK BIM. Included is basic guidance about what Level 2 means, but also some thoughts on the future.

We are on the brink of the most profound and far-reaching transformation of our industry since the First Industrial Revolution. This *Handbook* is intended to help you begin that journey, and I commend it to you.

James Wates CBE, FCIOB, FRICS, FICE, FCGI, FRSA

James joined Wates Construction in 1983 and the Wates Construction Board as Marketing Director in 1994. He was appointed to the Wates Group Board in 1997 and became Chairman in 2013. He is Chairman of the Nominations Committee and until April 2013 was a member of the Remuneration Committee.

Outside the Group James is involved with several industry bodies. He is Chairman of CITB, Chairman of UKCG, Chairman of the BRE Trust, Past President of CIOB, a Member of CBI and a Non-Executive Board Director of Argent Services LLP.

James is also Chairman of the Prince's Trust Built Environment Leadership Group, Vice Chairman of the Queen Elizabeth's Foundation for Disabled People, a Governor of the Emanuel School and a Governor of the University of Westminster and a patron of the Wates Family Enterprise Trust. In January 2012 James was awarded the CBE for services to Construction and the charitable sector.

Introduction

‘ … Building Information Modelling … ’

A phrase that creates fear, generates confusion and misconception, and is polarising our industry into those that do, those that don’t, perhaps those that really don’t care, and maybe those that would rather it just all went away!

For many thinking about starting their BIM journey, the difficulty is knowing where to start, achieving a basic understanding and then working out how to move forward.

The aim of *The Construction Managers BIM Handbook* is to provide some basic guidance, to cut through the misconceptions and provide CIOB members and the wider industry with a platform to progress.

This is deliberately intended to be concise, topical and a little basic.

With the help of some distinguished contributors, we will shed some light on the different aspects of BIM, unpack UK BIM Level 2 and explore what it means. This isn’t necessarily for the ‘experts’, as I believe those that are trying to just understand ‘which way is up’ will far outnumber the early adopters and leading protagonists for several years yet. Our challenge is to transform an entire industry, dragging it by its bootstraps into the twenty-first century and beyond.

Let’s be direct. I believe there is a tendency to over complicate this. To be bamboozled by the technology, excluded by the language and terminology, and blinded by the smoke and mirrors of media and PR. Perhaps some people would prefer you to continue believing that! There is money to be made in promoting the myths of complication. At its core, BIM is very simple – working together, collaborating seamlessly, efficiently, exchanging and using digital information all around the asset lifecycle.

Of course, like any change and working processes, there are rules and guidelines that need to be followed. Naturally, much of our thinking in this *Handbook* will be around process and technology, but we will also consider people. Fundamentally, BIM is about collaboration and sharing information around the asset lifecycle supported by a conducive culture and environment. Successful teamwork is achieved by *people* working successfully together. The technology as yet does not do everything for us! This soft underbelly of our industry is rarely consciously considered, yet we bump into this every day, whether we know it or not. The technology

and the processes/standards are perhaps the easy part of the equation, which looking from the outside some may find hard to believe.

We will look at the key BIM Level 2 documents and processes, and some of the technologies involved. We will also consider some broader contextual issues, such as education, the impact of the digital tsunami and the future of our industry.

The recent publication of the Digital Built Britain – Level 3 BIM Strategic Plan, 2015, points to the way forward way beyond 2016 – connecting and joining up sectors and industries on a global scale, in digital environments and communication. Whatever you call it, the Cloud, Common Data Environments, BIM, Smart Cities, Digital Built Britain, this is transforming the way we live, work and play – how things are and will be – the community of our existence.

The tidal wave of digital living will continue to impact across our industry for many years to come, in time affecting professions, institutions and academia. Other industries have made this transition over the last few decades; the built environment industry is perhaps the last major bastion of analogue thinking and working. But this is changing – rapidly! While the industry changes around us, Project, Design, Construction, Operations, Facilities and Information Management are all roles that will change and morph in the BIM environment, affecting businesses, organisations and our careers.

We have reached the 2016 UK target for Level 2 adoption. Key government departments have BIM embedded in their processes. For the rest of our industry, the picture is much more mixed with some beacons of excellence that still represent the minority experience.

If we keep on doing the same old things then we will always get the same results. In the past we have tried to improve existing methods a bit more each time, and while we might have leveraged small improvements, these aren't on a scale to make any real difference. Surely deep down we know that our industry can be better, *should* be better, in all kinds of ways. Our industry is under fire and pressure from many quarters and there is an urgent need for change, improvement, more respect and better quality. BIM is not the golden or silver bullet, but it is a catalyst that will help us leverage improvements and benefits.

We have a long way to go in establishing BIM Level 2 as business as usual, particularly among the various tiers of the supply chain and SMEs. I believe that the CIOB has a significant role to play in leading the change to a digitally based industry operating at UK BIM Level 2 and beyond. This *Handbook* is offered as a contribution to that journey.

JOHN EYNON

PS: Note to the reader

How you read this book is entirely up to you (of course!). However, while you could read it cover to cover if you wish, that isn't the way it's been written. Each section can stand alone to a lesser or greater extent, so you can dip in to it as and when, depending on what topic is hot for you at the time.

The *Handbook* is intended as a jumping off point for your own #BIMjourney and learning. We've provided some thoughts, comments, basic explanations and further resources.

There is no short cut here.

We will all have to become technicians and technologists in some measure, not only understanding the details of our own discipline but also how, in the BIM world, it works for us. With that comes the territory – we need to understand the regulation, standards, process and technology appropriate to what we're doing and our own role/activity. So in a way it's back to school for us all – unless you're Gen Z in which case you know most of it anyway!

Also remember we've included some information that you can find on the Internet anyway, but we've reproduced it here in the *Handbook*, to save time and collect useful information together for reference.

Good luck and best wishes – J.

Acknowledgements

Where to start?

First, the guys at the CIOB – Saleem Akram, Eddie Tuttle and the team – whom I've always found fantastically supportive and encouraging. If I've achieved anything over the last few years, then in some way most of it is due to you!

Second, the publishing team at Wiley Blackwell led by Paul Sayer. Bringing any publication to birth is a process fraught with angst and this one has been no exception – so thanks!

To my wife Anne Marie who has put up with me working on this at all sorts of odd times with longstanding patience.

And finally, in my own #BIM journey over the last few years, I've been very fortunate to rub shoulders with people who are leaders in their field. In the spirit of BIM, this book is a true collaboration and, as the list below shows, it is down to some pretty amazing, distinctive and inspiring contributions, from leaders in their respective fields – thank you! You have made this happen.

The guest contributors are:

James Wates	Foreword
Phil Jackson	Infrastructure
Anne Kemp	Collaboration
Saima Butt	People
Stephanie Kozandiak	B555 Roadmap, with permission from BSI
Stephen Hamil	Digital Toolkit
Sarah Rock	Legal
Kath Fontana	Facilities Management
Steve Race	Digital Security
Mark Bew	Beyond Level 2
Richard Threlfall	The next construction revolution
Stephen Emmitt	Design Management
Fred Mills	Social Media
Alison Watson	Education
Rob Jackson	Dictionary/Acronyms

And finally thanks to the guys at Autodesk, Bentley, Codebook, Graphisoft, Vectorworks, Synchro, and Tekla.

Glossary

BIM has its own language, full of terms, acronyms and at the outset a puzzling plethora of terminology which in itself is an enormous barrier to getting involved.

Rob Jackson and the team at Bond Bryan Architects have produced *The BIM Dictionary* and *BIM Acronyms* that are reproduced in full with their permission in Appendices A and B.

The beauty of these documents is that they are in plain English and are based on UK standards and terminology.

This is a tremendous piece of work by Rob and his team, and in the true spirit of collaboration has been freely contributed to the industry.

At the time of going to press these are the latest versions, but they are being continually revised and you can access current versions here:

http://bimblog.bondbryan.com/document/

And there is an online version published here by Darren Lester at SpecifiedBy:

https://www.specifiedby.com/resources/bim-dictionary

My thanks to Rob and Darren who have saved me a huge amount of work!

Very well done guys!

Notes on Contributors

Any project is a team effort. This *Handbook* is no exception and I'm delighted, fortunate and grateful, to have been able to enlist the help of the following contributors, who are leaders in their field in their own right.

BIM = Collaboration!

Thanks to you all for your specialist contributions that have filled in the context for UK BIM Level 2 and the way forward.

Mark Bew MBE

Mark is the Managing Director of Engineering Construction Strategies and Chairman of the UK Government BIM Task Group and BuildingSMART (UK). He is tasked with the delivery of Building Information Modelling and Soft Landings into the UK Public Sector by 2016. The programme was awarded the International Fiatech award for outstanding leadership and innovation of a programme recognised as world leading.

Mark is a Chartered Engineer with strong technical and commercial skills and a BSc in Computer Science. He is currently researching the use of BIM to improve the social outcomes of the built environment for a PhD.

Mark was previously Business Systems Director at both Scott Wilson Group and Costain Group plc, and has held positions with John Laing, Kvaerner Construction and GEC Avionics. He was awarded the MBE for services to construction in January 2012.

Saima Butt

Change Advantage was founded in 2001 by Co-Directors Aamir Ahmed and Saima Butt, driven by their belief in the limitless potential of individuals, teams and organisations. Drawing on years of valued practical experience in leading and developing teams in industry, and applying their unique mix of intuition, energy and humour, they aim to bring out the best in every person they work with.

Saima's corporate experience in the pharmaceutical industry was followed by an MBA at the OU. She coaches and mentors senior executives and holds a Master Certified Coach (MCC) credential with the International Coach Federation (ICF), an elite band of coaches internationally. Her work also takes her around the world as an ICF accredited Coach Trainer and Certified Mentor Coach, teaching professionals how to become successful coaches in their own right.

Stephen Emmitt BA (Hons), Dip. Arch., MA (Prof. Ed.), PhD, Architect

Stephen is an architect and Professor of Architectural Practice at the University of Bath, Department of Architecture and Civil Engineering. He is Director of the Department's Centre for Advanced Studies in Architecture (CASA) and Editor-in-Chief of the *International Journal of Architectural Engineering and Design Management* (AEDM). He is the author of numerous books and articles on design management and architectural technology. Prior to entering education, Stephen worked as a design manager, and that experience continues to underpin his interest in the challenges of collaborative working in temporary project teams.

John Eynon

John is a journeyman architect and design manager, having spent over 35 years in the AEC industry.

Over that time he has worked in the public and private sectors, and for 15 years in total worked with Carillion and Wates in Design Management and Work Winning.

He works with Class of Your Own and Surrey SATRO, and has lectured at various universities including Bath, Loughborough, Reading and Northumbria. He is now a PhD research student at Leeds Beckett University, looking at the impact of BIM and also team collaboration.

During the last five years he has become increasingly involved in the UK BIM agenda. He chairs the South East Regional BIM Hub, is involved with BIM4SME, represents the CIOB on BSI B555 and other industry groups, and works with the CIOB on BIM and regional presentations/workshops. He is a BRE Academy BIM Accredited Professional.

He is author of *The Design Manager's Handbook*, published by Wiley Blackwell in 2013.

Through his own consultancy, Open Water, he provides services related to BIM, Design Management and Work Winning.

He lives on the south coast with his wife Anne Marie and children, including various dogs and cats and a fire bellied newt.

Kath Fontana BA (Hons), Cert IOD, FRICS

Kath is a Chartered Facilities Management Surveyor with 25 years' experience of delivering Facilities and Asset Management solutions working for blue chip companies such as Serco, Aspire Defence Services, Interserve and most recently BAM FM Ltd, a wholly owned subsidiary of BAM Construct UK. She has extensive experience of managing complex programmes and service delivery at senior level across a range of sectors and within various contracting arrangements, including PFI.

Kath has particular experience in managing the interface between construction and FM and as a result she is passionate about innovation, integration and the whole life

management of buildings. Most recently, she has been instrumental in developing BAM's integrated construction/FM strategy.

She is active in the development of professional standards, being Chair of the RICS Professional Group for Facilities Management, Vice Chair of the Government's BIM4FM Group and a member of the BSI Advisory and Technical Committees for FM. Kath is a mentor on the FLUID Diversity Programme and a regular speaker at industry events. She was a finalist in the 2014 Women in the City Awards.

Adrien Guillemet

Adrien Guillemet is the 5D (BIM) Information Manager at Henry Riley LLP. He joined the company in 2014 as the KTP Associate attached to the University of Reading, where his main research focus is 5D BIM Quantity Surveying. He was born in France, where he holds an MSc in Mechanical Engineering, and then moved to Canada, where he studied Civil Engineering with a special interest in BIM and computer vision. Now at Henry Riley in Croydon, he is responsible for BIM development and projects within the company.

Stephen Hamil

Dr Stephen Hamil is Director of Design and Innovation at NBS. Stephen first started working on NBS products in 1999 and has played a big part in the developments of products such as NBS Building, NBS Create and the National BIM Library. He is the project lead for the BIM Toolkit project, which will complete the Level 2 BIM suite of tools for the UK Government's BIM Task Group. Prior to joining NBS, Stephen studied at Durham University. His first degree was in Structural Engineering followed by a PhD in the digital modelling of building structures.

Phil Jackson BSc CEng FICE FRSA

Phil is a Fellow of the Institution of Civil Engineers with many years of practical experience in design and construction. He is an acknowledged leader in the deployment of Information Technology in Infrastructure Design, Construction and Operational Management. His background and experience has encompassed most aspects of the construction industry, from buildings, through infrastructure, to asset management.

He is passionate about the use of data as an asset and seeing it used throughout the lifecycle of the built environment. And he feels strongly that BIM has too long been seen as a 3D modelling solution and not the information management tool it really is. He is therefore actively involved in helping asset owners, designers, builders and operators develop strategies that capture manage and leverage this information.

Over his career, Phil has been involved in some of the world's most prestigious projects, including the UK Channel Tunnel, Hong Kong's Airport, Heathrow Terminal 5, Dubai Festival City, Masdar City in Abu Dhabi and London Crossrail.

He is a member of the London Crossrail BIM Advisory Panel and has worked with the UK BIM Task Group as a team member developing strategy and supporting the delivery of BIM to Government departments majoring on BIM for Infrastructure for the Highways Agency and the Environment Agency. Most recently, he has joined the Atkins team assisting the UK High Speed 2 Rail project in implementing information management solutions to the project.

Phil runs his own independent consulting company and is Royal Academy Visiting Teaching Fellow for BIM at the University of Surrey. He also chaired the Institution of Civil Engineers Information Systems Panel for a number of years, is a board member of Building Smart UK, and serves on a number of standards steering groups related to BIM.

Rob Jackson

Rob is a qualified architect and has delivered projects in the education and advanced manufacturing sectors.

His significant project experience and passion for technology resulted in his selection for a number of special projects, including the development of the quality systems and office intranet facility. This work then led to his current role of BIM Manager.

He speaks at both national and international events as a passionate advocate of an open BIM approach, exploring the sharing of data between different software packages via the 'IFC' open format and promoting industry wide standards that enable full collaboration between different parties.

He chairs the sub-committee for the AEC (UK) BIM Protocols for GRAPHISOFT ArchiCAD, is a member of the buildingSMART UK's Technical Group, an ambassador for thinkBIM at Leeds Beckett University, tweets and also writes Bond Bryan Architect's BIM Blog.

Anne Kemp

Dr Anne Kemp is an Atkins Fellow and Director at Atkins, responsible for BIM Strategy and Implementation across the UK. She has been working in the industry for 25 years, delivering information to where it is needed for informed and intelligent decision-making. At the start of 2015, she became Vice Chair of BuildingSmart UK, having completed two years as Chair for AGI, where she remains as an active member of Council. She is Chair of ICE's BIM Action Group, and BIM4Infrastructure UK. She has been part of the UK Government BIM Task Group helping the departments to implement BIM, in particular the Highways Agency and Environment Agency, and recently graduated as a prizewinner for her MSc in Coaching and Behavioural Change at Henley Business School, focused on enabling sustained collaborative working.

Fred Mills

Fred Mills is Founder of The B1M ('BIM one million'); a free BIM video resource that is inspiring one million people to help mobilise widespread BIM adoption. Fred has grown The B1M into an award-winning social enterprise business that now reaches people across six continents. He lives in Surrey with his family.

Steve Race

Steve Race is currently a Lecturer at Middlesex University assisting in the delivery of the MSc Building Information Modelling Management Course. He recently represented the Royal Institute of British Architects as a co-contributor to a new and first Code of Practice for Cyber Resilience in the Built Environment, carried out under the auspices of the Institute of Engineering and Technology.

Between 2003 and 2006 he was one of two lead consultants on the Government funded programme Avanti, whose brief was to facilitate project teams in the implementation of BIM.

Between 2006 and 2011 he taught Management Practice and Law at Degree and Diploma levels at Oxford Brookes University and was also the Programme leader for the Part 3 examination, which is the final stage of architectural qualification before entry to the architects' legal register.

During 2012 and 2013, he was the BIM Hub Ambassador and a member of the BIM Task Group, Core Management Team, both concerned with delivering the Government's message on BIM.

For 40 years he has been involved in a wide variety of national and international, ground-breaking projects in cooperative working supported by IT, currently called BIM.

Sarah Rock

Sarah Rock is a member of the Construction and Projects team at RPC. She acts for clients in the resolution of construction-related disputes as well as advising clients through the various stages of construction transactions and has experience of drafting and negotiating core and ancillary construction documents.

Sarah advises on the legal aspects of BIM and has spoken at various conferences on the subject. Sarah tweets regularly about BIM as well as writing BIM related blogs and articles. She is a named contributor to the Chartered Institute of Building's Complex Projects Contract having assisted with the drafting of the BIM clauses.

Prior to entering the law, Sarah worked in the construction industry as an electrical contractor and also ran her own CAD engineering business.

Richard Threlfall

Richard is UK Head of Infrastructure, Building and Construction at KPMG and has over 20 years experience in the financing and structuring of infrastructure projects.

Before joining KPMG, Richard was at Citigroup, and before that he was employed as a civil servant at the UK Department for Transport where he held positions in the road, rail and aviation directorates. Between 1996 and 1998 he was Private Secretary to the Secretary of State for Transport and the Deputy Prime Minister.

Richard leads KPMG UK's Corporate Finance Infrastructure business and he sits on the KPMG UK Corporate Finance Board. He is Chair of the Advisory Council of the Infrastructure Forum.

Alison Watson

Alison is a topographical surveyor who, after working on the Building Schools for the Future programme, decided to write an alternative digital built environment learning programme to inspire young people and their teachers to discover a wide range of technical and professional construction careers.

She set up the education company Class Of Your Own Limited in 2009 to provide industry led applied learning activities and to promote the construction industry as a 'career of choice' destination.

Alison created the innovative 'Design Engineer Construct!' (DEC!) learning programme for secondary schools, and the embedded suite of qualifications now provides accreditation at Level 1, 2 and 3, is included on DfE performance tables with GCSE and A level equivalencies and attracts UCAS points at Level 3. The programme is cited in the UK Government's Construction 2025 Strategy and is now supported by some of the UK's leading AEC companies, professional bodies and universities through her ground breaking 'Adopt A School' scheme, recently commended by the Government's Chief Construction Adviser.

Alison was presented with the highly respected Richard Carter Prize by the Chartered Institution of Civil Engineering Surveyors in 2014 and The Survey Association's President's Award in 2013 for her commitment to education and raising the profile of surveying and engineering. In recognition of her activities, she has recently been selected to represent Youth and Learning on the 2015 CITB Council.

Part I
INTRODUCTION

Chapter 1

What is BIM?

John Eynon

In starting to think about BIM and what it is, let's consider the following definition:

> Building Information Modelling is the digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about it and forming a reliable basis for decisions during its life cycle, from earliest conception to demolition.
>
> (This definition by CPIc is based closely on the US National BIM Standards Committee (NBIMS).)

Note that it mentions digital representation, sharing knowledge, reliability, decision making and lifecycle.

Remember: this is about much more than a 3D geometry model. It is about all asset information around the asset lifecycle.

Remember too that there can be many kinds of models – financial, data, planning, logistics, environmental and also geometric/graphical (3D).

In BIM, or perhaps we should use the term Common Data Environment (CDE[1]), we can begin by standing back from this and looking at it in a different way.

Let's consider Figure 1.1.

I'm sure we are familiar with the basic stages of a project, and our role in it, whatever it may be. Someone has a need, or an idea, they write or get a brief written. Someone produces a design; it is procured and then bought. It is then made and installed, or constructed, and then finally handed over to the owner and operated or used. This could apply to anything, a ship, plan, nuclear power station, tunnel, road, gas pipe or even a building.

I'm also sure that whatever role you or your organisation have in this process, you know where you fit and operate in this cycle of brief, design, construct and operate.

Let's take this a step further. Now consider all of the information that is produced at each stage and is then handed on to other stakeholders for their work, and so on. A web of information is woven from a very early stage on any project, which over its lifecycle will fill several filing cabinets and, on larger projects, a warehouse!

[1] CDE refers to the terminology of the BS1192 series. Check out BS1192:2007.

Construction Manager's BIM Handbook, First Edition. John Eynon.

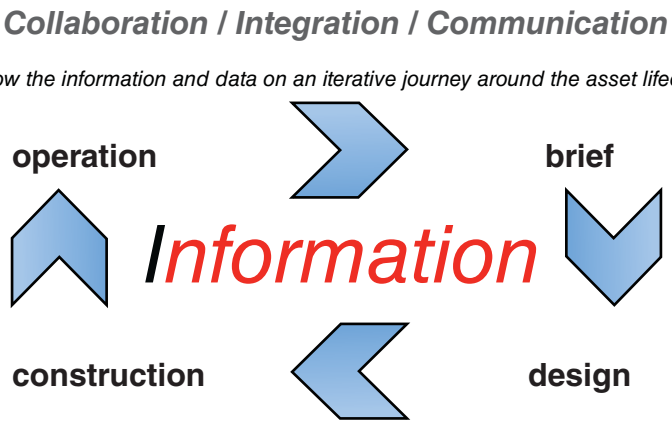

Figure 1.1 Project process in four basic stages.

Consider then your own role and your own organisation. What do you do? What information do you use and/or produce? How do others use your information, what do they return to you and how do you then use that information? How do you collaborate and work together?

In trying to understand the information flows, it is these sorts of questions you need to be asking. You need to understand how you engage with the project information in your role.

As we have seen, this is about 'following the information and data on an iterative journey around the asset lifecycle'.

Once you have an understanding of how you use and interact with the information, you can then begin to think about how this looks in a BIM or CDE.

Remember that in a CDE (BIM) information is digital; it is shared around the team and stakeholders; and, when working in this way, we need to be consistent and coordinated in how we use and produce information. This can then lead to increased efficiency and reduced waste in our working simply because we are reworking information a lot less, and increasing the reliability of what we're working with and thereby informing the decisions that we're making.

As we shall see later, there are many aspects to how we can work with the digital information, producing simulations and reports at the press of a button. New apps and plug-ins are being produced almost everyday.

The beauty of this approach is that we are sharing the same information source on the project – the term *single source of truth* is often used. In BIM, information created on one project can then be used or referred to for the next project much more efficiently. This is where libraries of data and objects come into their own – an approach used by retailers, for instance, in standardising the kit of parts, products and components for their stores.

So, before we get bamboozled by BIM technology, the buzzwords and the jargon, we just need to remember this simple idea of understanding the project information flow and our part in it when working with the other stakeholders.

We need to understand what is produced, who by, what for, what they do with it, who receives it, what they do with it and so on. It is then possible to lay BIM workflows and digital tools over this to see how it works in a CDE.

So … things to think about:

- Understand your role.
- Understand your organisation.
- What information do you produce?
- How do you use it?
- What information do you receive from others?
- What do they do with it?
- And repeat … repeat!
- Remember: BIM is about much more than technology and 3D.
- Where do you fit in the team?
- How do you work and engage with other members of the team?

Chapter 2

Why BIM?

John Eynon

Why BIM? These days you might well argue: why not?

Would anyone think about not using CAD, or the internet or email? It's the way we do things. In time it will be just the same for BIM, and in fact we won't even use the term BIM anymore. We will have moved on to whatever's next.

In fact, I wonder whether we are approaching a time (perhaps it's here) when the incessant Return On Investment calculations, need for business cases and so on, become irrelevant and redundant as this is now simply how the industry works and otherwise you will just get left behind and go out of business.

It's digital or bust baby!

As discussed later in the *Handbook*, there are as many, if not more, drivers for working in digital environments lying outside the AECO industry than within.

So, other than this, 'why BIM', really?

We need to consider:

- the UK Government mandate
- benefits
- digital context.

2.1 The mandate

The Construction Strategy, published in 2011, said this:

> 2.32 Government will require fully collaborative BIM Level 2 (with all project and asset information, documentation and data being electronic) as a minimum by 2016. The staged plan will be published with mandated milestones showing measurable progress at the end of each year.
>
> (Government Construction Strategy 2011: p. 14.)

This led to the formation of the BIM Task Group, the development of the standards that we will look at later, and processes and so on.

It is interesting to consider whether BIM would have been so high on the industry agenda, at a time when we were coming out of the deepest recession in living memory,

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without the mandate to keep it bubbling along. The articulation of the case and the setting of the 2016 target for the public sector kept this a live topic at a time when most organisations might have had other priorities if left to their own devices.

A big stick!

2.2 Benefits

Now to the carrot!

The recently reissued BIM Delivery Cube,[1] articulates the benefits available to all stakeholders in the process, at each stage.

Some contractors use the phrase 'build it twice'. In other words, build the project once virtually and then build it for real.

VDC (Virtual Design and Construct), as it is known in the USA, is just that. This is the idea of eliminating all the risks and potential issues in the virtual environment before actual physical construction starts.

So, through clash avoidance and clash detection strategies, clashes or construction problems between packages or elements can be resolved.

As the design process develops and moves from stage to stage, information can be seamlessly transferred, developed and validated. This avoids a lot of the waste in time and effort that used to occur because of rework of previous stages or completion of work not done.

As the single source of truth on the project, the project BIM is the repository for all information – consistent, classified and coherent. This alone reduces waste in the team's efforts, as information is coming from a verified source and being used consistently.

And, of course, the real benefit lies in the Facilities Management lifecycle. If you're aware of the work of Richard Saxon and Constructing Excellence on this then you will know the cost of an asset over its lifecycle is many times the cost of its design and construction. If through the use of BIM technologies and tools we can make intelligent decisions about the asset lifecycle (Figure 2.1), we can create considerable value for ourselves and our customers.

These, perhaps, are just a few benefits, but reduction of waste and risk, saving of time and effort, and reuse of reliable, verifiable, consistent information through libraries and BIMs will very soon have a great impact on us, the way we work, our projects, and the end results.

2.3 Digital context

As we will consider in the Afterword, we are now living digital lives. The migration of the AEC industry into the use of BIM/CDE environments is simply following the well-worn path of other sectors and industries. This makes possible the Internet of Things, the Internet of Everything, and all the data and information that we consume, use and trade on a daily basis – being available to all 24/7 – resulting in a true digital information

[1] http://www.ciria.org/bim/cube.aspx.

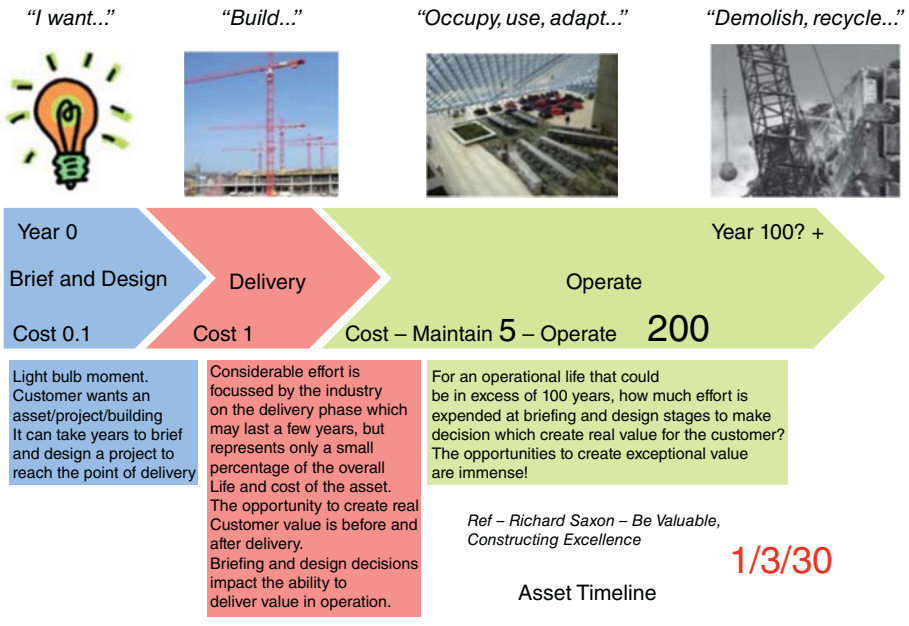

Figure 2.1 Lifecycle asset value chain.

economy as envisaged by the Digital Built Britain strategy for UK BIM Level 3 and beyond.

Chapter 3

BIM, Buildings and Infrastructure

John Eynon

AIM	Asset Information Modelling (Whole Lifecycle)
BIM	Better Information Management
BIM	BIM
BIM	Building Information Modelling
BIM	Building Information Management
BIM	Business Information Management
BIM	Building Information Movement
CDE	Common Data Environment
DE	Digital Engineering
VDC	Virtual Design and Construct

BIM is an unfortunate acronym, but we are now stuck with it as it is the only universally recognised term for talking about digital information modelling environments. Most people get the subject area even if they don't always agree on the details.

As we know, BIM is not just about buildings; it takes in any kind of built, made or constructed asset, such as infrastructure, a power station, a tube station, a gas pipe, an oil rig, a shop, a plane, even a space station.

Nor is it just about the building stage; it covers the whole lifecycle of any made or constructed built asset in the environment. And remember: a model isn't just 3D geometry. You can have a financial data model, maintenance information model, thermal, environmental and so on.

As early as about 1970 Nicholas Negroponte, at MIT in the USA, was talking about digital architecture. This is not new technology. Perhaps the most notable recent example of BIM technologies in an adjacent industry is the design, production and manufacture of the Boeing 777 airliner. Boeing assembled their supply chain in a digital environment to design, test and construct the aircraft.

As much as we argue that BIM is more than 3D, it has to be said that if our industry could simply master 3D BIM then there would be immediate benefits in improved

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coordination, less waste and abortive work, and improved project delivery. It wouldn't be a bad place to start!

BIM is truly about creating, maintaining and using information and data, seamlessly and efficiently, by all stakeholders over the entire lifecycle. This includes brief, concept, design, procurement, manufacture, construction, commissioning, handover, operation, maintenance, refurbishment alteration and extension, and through to eventual recycling.

'Common Data Environment', the term used in the 1192 series, is perhaps the more correct way of looking at this: all data, over the lifecycle, in a common environment, available to all. Organised, coherent, consistent, transferrable, efficient.

As the information is in a digital form, it means that we can do clever things with it – some of which you will know already.

3.1 3D geometry

Most of us will be familiar with 3-dimensional geometric models of the building or structure. Improving design and coordination through clash avoidance and detection tools, also used as a basis for visualisations and fly throughs/around, is now commonplace. Taking each of the discipline design models, it is possible to aggregate the models into one environment and identify clashes and conflicts between the discipline designs. Whether this is one totally integrated model or a 'federated' model composed of several models is under discussion. Certainly, the federated approach reduces file sizes and lessens the impact on ICT infrastructure, which is a big consideration in implementation. It is possible to federate models produced by different software, through use of a package such as Navisworks or Solibri, which will enable clash detection. It is also possible to use IFCs to import a model into another package. There are varying reports on how successful this can be, but certainly the future will be about more interoperability between platforms and the use of IFCs.

3.2 4D time

This is the generally accepted '4D'. It is possible to assign time attributes to parts of the model so that a view can be generated that shows the construction sequence. Into this can be added elements such as cranes, hoardings, scaffolding, hoists and so on. Most of us have probably seen these animations. Generally, these are used to explain the construction sequence and site logistics to, say, a client, site team or supply chain. This is particularly useful for understanding the requirements for the construction sequence and the implications in 3D. It is possible for the 4D model to interact with the main planning platforms, such as Asta and Primavera. It is not only possible to generate a planned sequence, it can also be used to visualise current progress. Site Managers using Field BIM on tablets can record progress on site, then synchronise with the BIM/CDE and you have an up-to-date view of where you are on the programme.

Another advantage is that alternative scenarios can be quickly modelled and evaluated for, say, sequencing or different construction methods.

3.3 5D cost

Once the model is designed, even in outline, it is possible take off quantities for elements or components. The output can be in a form that cost planning or estimating software can accept, although how this actually works needs to be defined upfront to make the technical aspects feasible. Over time, as libraries of project-based data are established, this will enable information to be accessed to compile cost plans quickly and efficiently.

It is worth noting that the use of libraries of information to populate the model and database is a great factor in improving the efficiency, speed and reliability of the project process.

3.4 6D FM and lifecycle

The project BIM is updated to as-built at construction completion. Loaded with the O+M information, this can then be used by the customer's FM team to manage the asset, as the AIM – Asset Information Model.

This aspect is part of the UK government's drive on BIM adoption for the industry. If consistency of data is applied across the public sector estate then this can be harnessed to result in increased efficiency and management. This is where GSL – Government Soft Landings – comes in. However, planning for the GSL process begins in the early stages of design. GSL is one the key 2016 targets for the public sector.

As discussed earlier, the BIM can be accessed using handheld tablets so that managers walking round the asset can retrieve and also update information. The use of barcode readers and scanners enables quick access to relevant information on particular items of plant or equipment.

Using plug-ins or additional software packages it is possible to run simulations of the lifecycle, looking at carbon emissions, energy consumption and so on. Therefore, from an early point in the design process, decisions can be made from an operational perspective to develop the optimum solutions.

The use of tablets has been extended into snagging and defect logging following similar principles.

3.5 Simulations: lighting, fire, people movement, thermal, carbon, energy

In addition to the basic 3D design packages, there are additional plug-ins and various packages that can use the model to simulate various conditions, such as lighting levels, fire performance, the movement of people – including lift simulations and queuing patterns, thermal losses and transmittance, carbon emissions and energy consumption. In compiling the model, the relevant data will need to be input as attributes to elements or components to enable the functionality required. But again, as libraries of data are developed, the input activity can be accelerated.

3.6 Operations + maintenance manuals and information

The project BIM can be used as a means of storing and accessing O+M and CDM Health and Safety File information. This can be made available to a handheld tablet – so by going into a room, you could call up the room data sheets, relevant manufacturer's information and so on. If, say, an item of plant or FFE has a barcode or an RFID tag, then this can be scanned and used to access the information on that item, such as dates of manufacture, installation, defects period, maintenance and any other related information you care to choose to have stored.

3.7 Visualisations

This is another aspect that is probably familiar to most people: visualisations of the design model, utilising stills from selected 'camera' views or animated fly-throughs around the site and building. These are particularly useful in explaining the scheme to customers or stakeholders and also for explaining it to the planning department or other interested parties. It is possible to have a fully virtual, immersive experience with headsets, goggles and gloves, so that you experience the model from inside.

These kinds of animations are extended into the construction sequence animation discussed above.

3.8 Site safety planning

Some contractors use the phrase 'Build it twice' – that is, build the project virtually and then go and physically build it. As the BIM model becomes more detailed and contains the construction status information, then it is possible to review the construction process in detail from a safety perspective, considering sequences, access requirements, particular areas that may require special temporary works or other factors. This takes risk assessment to a new level, enabling teams to view how to construct virtually before going out into the field to actually do it.

3.9 Fittings, fixtures and equipment

Having designed the 'base-build', it is equally straightforward to design in FFE requirements, link these to a room data sheet package such as Codebook, and link to procurement, O+M information and so on.

Manufacturers are beginning to produce libraries of their product ranges, which will make it easier for designers to incorporate them in their models. There are library sites being developed such as NBS BIM library and the BIM store.

3.10 Offsite manufacture

Having developed a detailed, clash-free data model, subcontractors can retrieve the information they need to manufacture their elements and components. In

some cases, the data can be exported straight to CNC-enabled plants that enable computer-generated manufacturing processes. Double or triple handling of information is avoided and information is taken direct from the model to facilitate the process. As supply chains develop object libraries of their systems and components, these can be made available to designers to incorporate within the design stage BIM. Of course, to the physical data can be added other attributes, such as procurement data, costings, lead in times, technical performance data to enable simulations and O+M information.

3.11 Lifecycle costing and management

Using plug-ins or additional software packages, it is possible to run simulations of the lifecycle looking at carbon emissions, energy consumption and so on. Therefore, from an early point in the design process, decisions can be made from an operational perspective to develop the optimum solutions.

It is a short jump from here to the next step …

3.12 Facilities management/building operations

The project BIM is updated to as-built at construction completion. Loaded with the O+M information, this can then be used by the customer's FM team to manage the asset.

This aspect is part of the UK Government's drive on BIM adoption for the industry. If consistency of data is applied across the public sector estate, then this can be harnessed to result in increased efficiency and management.

As discussed earlier, the BIM can be accessed using handheld tablets so that managers walking round the asset can retrieve and also update information. The use of barcode readers and scanners can enable quick access to relevant information on particular items of plant or equipment.

3.13 Recycling

At eventual demolition and/or recycling, the BIM can contain the information to enable safe demolition and also the material specifications for recycling, if required.

In addition, assuming the BIM is kept up to date, then should alterations or extensions to the asset be proposed then the BIM provides a good starting point for the new design team.

3.14 RFID (radio frequency identity tag)

These really are intelligent barcodes. A small chip can be fixed or embedded in a component or object. This can be then read by a radio frequency reader, which detects the barcode number, and can be used by the database to identify the object and call up any related information. One application is that through the use of scanners at site entrances, contractors can track deliveries of materials, which could link to the

progress-tracking element of a project BIM. Items of plant or furniture or other equipment can have unique identifiers, which enable the correct and relevant information to be called up from the BIM when scanned, as used by FM managers.

3.15 Refurb/retrofit

Much of the progress on BIM has been made on new-build, but now survey models are more readily available through the use of laser scanning technology.

Through the use of laser scanning stations, survey data is collected and converted into a 3D model to be imported into the BIM model. This provides greater accuracy earlier in the design process, and is also on a par with traditional survey methods costs. The Manchester City Library case study is a recent example. Incidentally, the same technology is being used to scan road accident scenes, speeding up the process of re-opening the roads to traffic.

So, here we can bust a few myths. First, BIM is not just for new buildings. It is for existing buildings too. Laser scanning technology and conversion to BIM models has radically improved over the last few years. There are several examples of universities and some developers converting their existing estate information into BIM environments.

Second, it is not just for large projects. There are examples of BIM being used on domestic extensions and improvements. In time BIM will just be the way we work, even to the point when we really don't use the term BIM any more. So it won't be a question of whether the project is large enough, it will be just what we do.

3.16 3D printing

Over the last few years, 3D printing has seen amazing growth in both technology and profile. It has implications outside the AEC community, for example it is being used for prosthetics and replacement body parts; on the International Space Station; and is being trialled by the US Navy for producing spare parts at sea. Recent construction examples include a Chinese example of making and constructing 10 houses for about £3000 each. Skanska are researching the use of a concrete 3D printer.

Eventually, I'm sure, we will all have a domestic 3D printer at home, and rather than buy stuff at shops we'll download designs and specs from the web and make it ourselves. Rather like the revolution in home PCs. We have some way to go yet, but I'm sure it will come about in time.

Industrial-sized 3D printers can make heavy duty items, such as construction components, cars – anything. Naturally, this raises questions about standards, longevity, warranties and all the small print. However, just like any emerging technology, this will be developed as industries drive the change.

3.17 Automated construction

Once we have digital design, we can have digitally enabled manufacture; and since we know where the components go in the finished construction in xyz coordinate terms, we can place the components using robotic tools. Semi-automated robots have been used in cladding installation for several years. A major contractor is looking at a semi-automated bricklaying robot. Particularly where offsite BIM driven manufacture has been used, it makes sense to use onsite BIM driven installation. There are probably more questions than answers at this stage, but lessons can be learned from the car industry and, just like 3D printing, I'm sure this will be a significant growth point over the next few years.

3.18 Validation and compliance

The digital information environment enables rules-based algorithms to check the model. This might be for presence of data, compliance with building regulations, clearances for safety and access around particularly pieces of services equipment and so on. Anything that can be reduced to a simple rules-based test.

Solibri is a rule-checking platform that offers compliance validation. The NBS Digital Toolkit will validate the BIM for particular stages in the digital Plan of Work to check that required information has been produced.

3.19 Infrastructure

While much of the 'Hollywood'-style BIM presentations and visualisations portray buildings, it is equally applicable to infrastructure – roads, rail, pipelines, tunnels and the like.

There is much common syntax between vertical and linear/horizontal assets, as they have become known; there also are particular terms applicable to those industries. Many of the challenges faced by the development groups over the last few years have been in developing a classification, a digital plan of work and a terminology that is inclusive of both sectors.

Nothing is set in stone, and these tools will continue to develop and evolve as our understanding and use of BIM grows. However, we have reached a point where there is enough common ground to move forward together as an industry rather than fragment into sectors, or disciplines even, which would be a futile and ultimately wasted exercise.

Phil Jackson, a key player in BIM infrastructure circles, talks us through BIM from an infrastructure perspective in Chapter 4.

Chapter 4

BIM and Infrastructure

Phil Jackson

4.1 Introduction

It is perhaps unfortunate that BIM (Building Information Modelling/Management) includes the word 'building' and that much early discussion on BIM has concentrated on its use for design of 'buildings'. If we are to realise the full benefits of BIM then its utilisation needs to be seen in a much wider context, and the term 'building' viewed as the verb 'to build' rather than the noun 'building'. If we understand 'infrastructure' to be the physical structure needed for the operation of a society or enterprise, or the services and facilities necessary for an economy to function, then it is clear that 'buildings' are a subset of infrastructure as a whole and infrastructure gives the overall built environment context. The often repeated adage that infrastructure is the horizontal rather than vertical aspect of the built environment is grossly incorrect and distinctly unhelpful in our implementation and use of BIM. Furthermore, linking infrastructure to just the civil engineering aspects of construction limits the application and use of BIM in the built environment. Infrastructure is the setting for the whole built environment and not just roads and railways.

A useful definition of infrastructure is: 'the set of interconnected structural elements that provide a framework supporting an entire structure of development'. As such it has direct interaction with its surrounding environmental context and its boundary conditions must integrate with that context.

4.2 In infrastructure the asset is the business

In general, in infrastructure the asset is the business rather than containing a business. As such, any information-led strategy must cover the full lifecycle of the asset being considered.

Rather than being a linear process, infrastructure asset owners' information can jump in at any part of this cycle and does not necessarily start with a 'new project'; indeed, most infrastructure construction starts with an existing asset and some demands to update and improve its performance. Many infrastructure asset owners spend significantly more on operational asset management than they do on new

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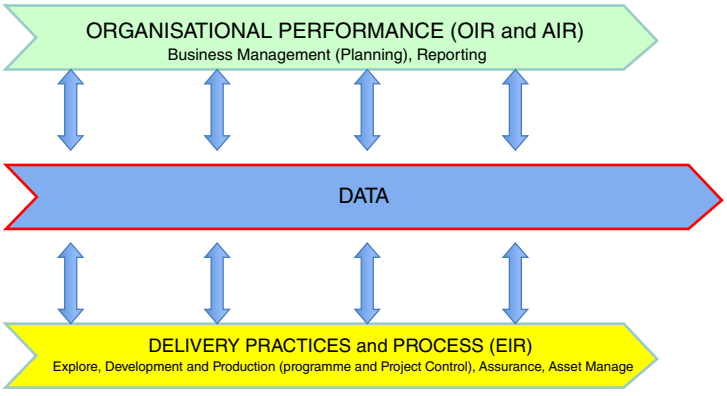


Figure 4.1 Data spine for organisation operation.

projects. Hence, any BIM for infrastructure must incorporate the changes that occur in operation – as well as those larger ones that occur in new projects.

Early BIM examples have centred around the creation of new assets and projects to undertake this, hence it is not surprising that most BIM thinking has focused on the 3D modelling aspects of design and construction. This is, of course, an important aspect of BIM and delivers many benefits; however, to reap the full rewards of BIM we need to see it as information through the whole lifecycle.

The approach, therefore, is one of capturing data throughout the lifecycle of an asset to support Organisational Information Requirements (OIR) that drive strategic and business decisions, Asset Information Requirements (AIR) that drive operational management performance and decisions, and Employers Delivery Information Requirements (EIR) that drive project delivery and handover (Figure 4.1). This data capture and management acts as an 'information spine' for the asset lifecycle.

This BIM 'spine' captures, manages and provides information not just about the components and assets that comprise a project but also provides information to support corporate business decision making, asset owning and maintenance, and project delivery management (Figure 4.2).

While these principles apply to all construction, they are particularly significant in infrastructure where there are few 'new projects' and even those that are new have to fit into existing infrastructure.

4.3 Infrastructure is messy

Infrastructure deals with the landscape in all its infinite variety and often is messy, moving and re-sculpting the earth surface – involving lots of mud, dirt and water – making discrete object definition difficult if not impossible. Rather than the tidy defined edges of buildings, in infrastructure it can be difficult to distinguish where one thing starts and another ends. While it does contain discrete components, it is often continuous and linear and not quite so easy to break down into logical chunks.

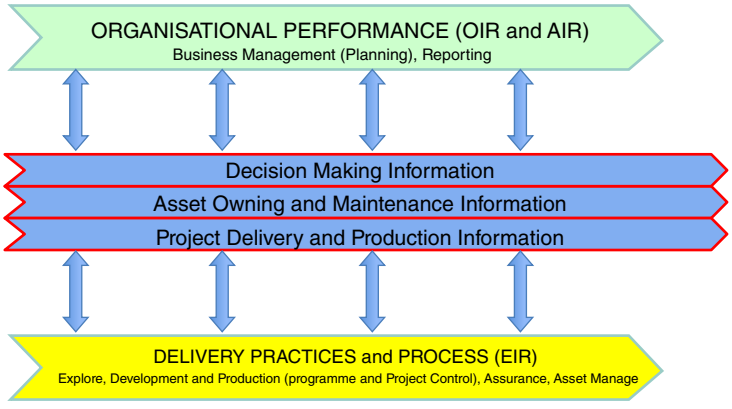


Figure 4.2 Data spine for AIR and OIR.

Infrastructure projects not only add new construction to the landscape, but also modify the existing landscape. Hence, in most cases, the first models encountered in a project are survey models – be they topological, ground surface, geological, environmental, land ownership or prediction models, such as traffic and flood modelling. And the final model handed back to operations is also a topological and surface model. It usually forms a new surface that sits within a contiguous landscape, which it intersects and interacts with to form new components by cutting away or adding to existing formation.

It will usually have multiple geological surface layers, regular and irregular, continuous and non-continuous. It must take into account geological faults, small intrusions like sand lenses and underground spaces. This impacts on the measured quantities, construction, structural integrity and performance of the asset, hence accurate modelling of surfaces is essential.

Many components are buried and form part of a wider network, often outside the site with wider connections, and can interfere with existing networks of underground assets with the related clash potential. Anecdotal evidence suggests that discovery and recording of existing underground assets accounts for a significant risk and cost to new projects and becomes very important when upgrading existing facilities.

While infrastructure has discrete components, these are often networked and continuous, requiring segmentation. The network aspect is important as it gives all components context, and actions on one element can impact others that are remote but connected. A good example is track possessions for railway work or traffic diversions. In some disciplines, these networks are expressed as schematic diagrams rather than geometrically correct representations. These representations of components need to relate to the real world ones and connect to the same data. Typical of these might be signalling schematics.

Many deliverables are defined as polygonal features, such as land ownership, noise contours, planting, drainage and catchment areas, ponds and environmental protection areas. Some of these component features are required for project delivery but

are not physical objects as such, rather geographic features that hold essential delivery and permission information such as might be required during public participation exercises, environmental studies, traffic or water flow modelling or simply for gaining access.

Infrastructure projects fit into a wider landscape of features including geography, landform, environmental, geological, archeological, drainage, flood plains, tidal ranges, vegetation, transport corridors, utilities and so on. While it might be easy to dismiss these as mere mapping, they are important components of an infrastructure BIM. Often characterised as Geospatial Features in GIS, they are part of the BIM model. Additionally, and to add complexity, some of these features are transient – that is they change with time and conditions. Good examples are flood plains or balancing ponds.

While buildings do have to deal with these issues, they are usually more a matter of planning and clearance rather than an integral part of the project, unless they are part of a campus such as an airport – though it could be argued that the nature of a campus is much more related to infrastructure than to individual buildings, which are part of the whole.

Introducing these infrastructure components into BIM in a coherent way is necessary but clearly not quite as straightforward as the components of a building.

4.4 Federated infrastructure models

Infrastructure suits the Level 2 BIM approach in that any model, be it 3D geometry or pure data, is made up of layers and distinct sets of information. So the building fits into the overall landscape, and to model the information that makes up the whole each layer adds data that can be combined (federated) to give the overall view.

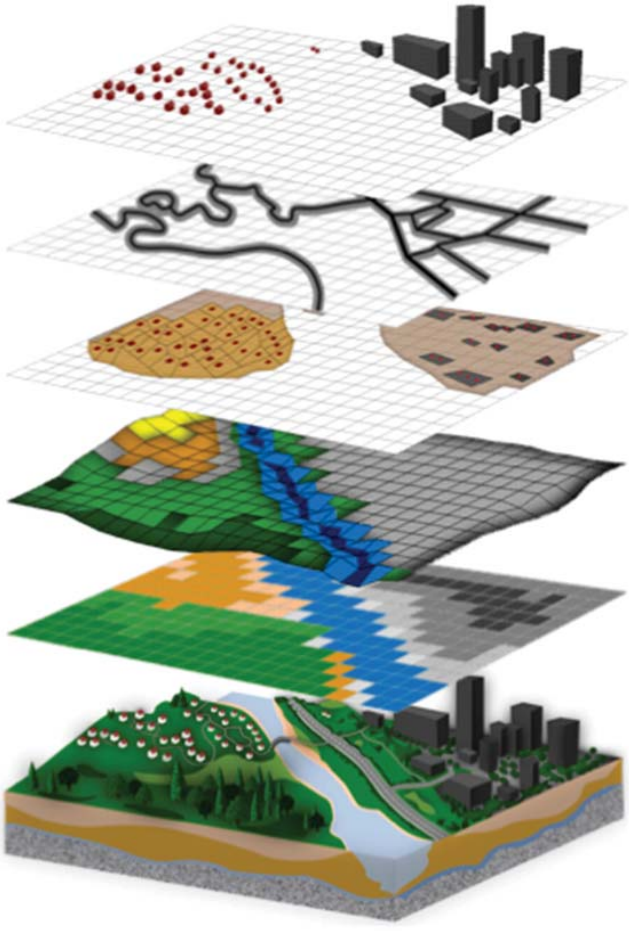
Hence an infrastructure BIM dataset may be made up from many different models, each coordinated and contributing to the whole.

Typical information models might include:

- survey model
- ground surface model
- utilities model
- geological surface models
- network and route models (traffic or water modelling)
- environmental model
- land-ownership model
- alignment model
- continuous linear entities model
- linear component model
- point entities/component model
- utility and drainage network model
- structural models – bridges, tunnels and retaining walls
- building models – structural, architectural, M&E

- rail signalling model
- asset information model.

The list here is not exclusive but drawn to show the principle of multiple models interacting with multiple applications to make a complete data picture. It follows that there is not, at least at present, a single application of modelling tool that can handle all the complexity and diversity required to meet the infrastructure world. Our approach, therefore, is one of creating 'open' federated and linked datasets created and edited by individual tools. In fact, our whole BIM solution must provide the capability of federating data from multiple sources to enable new solutions and applications to develop in the market, rather than plug-ins to proprietary solutions.



4.5 Specific infrastructure issues

There are a number of specific issues that arise within the infrastructure world that need to be addressed when data modelling.

- Geospatial location – infrastructure resides in a round world not a flat project site, hence particular attention needs to be given to:
  - World positioning and map projection systems with known translation methods.
  - Common coordinate systems.
  - A common grid with common origins:
    - not the building grid but a grid suitable for the project or its location (e.g. in London perhaps the London Survey Grid);
    - any specialist project grid must be related to and be capable of being federated with other models.
- Must be capable of locating and defining polygonal components, for example planting zone, catchment area and so on.
- Capable of defining a linear location – base line measurement – defining points where measured, require an LRM (Linear Referencing Method) and offset method for location.
- Definition of and subdividing continuous objects – segmentation – where a road starts and ends depend on use-case view. For example traffic engineering sections are different to design sections, signalling sections and maintenance sections.
- Handling variable asset values – attributes can vary along length.
- A consistent methodology for defining discrete objects from multiple surface models:
  - Many objects are defined by multiple surfaces, lines and vertices, not all of which intersect but need edge conditions to form objects.
- Definition of a discrete object will differ depending on at what stage of a project lifecycle the current action is being considered. For instance, a road design may break down in early stages to road sections between interchanges; whereas at construction it may break down into earthwork sections relevant to geology (rock, clay, sand etc), construction type or mass haul calculations; and at asset management and operation stage to cutting or embankment. So we need a model that can be recut to suit but retain its pedigree information.

- Of course, for many construction objects in infrastructure there are well-defined objects, such as bridges, tunnels, kerbs, safety fences and so on. These can be defined as Building Smart international foundation classes (IFCs); however, caution needs to be exercised as many IFCs tend to be able to define regular objects but complex shapes are not catered for.

4.6 Tools and data management issues

In general, GIS and infrastructure BIM tools lag behind those of building BIM. Many of these tools deliver line-based or surface-based, rather than object-based, information. Most certainly do not deliver structured data.

Many infrastructure design tools lock the user into a proprietary solution, which ultimately will restrict the wider use of BIM information. Some software tools are not conducive to federating data and try to work as a 'single' model, which leads to lock in. So care needs to be taken in software and data management choice.

While there are a number of defined, open standard objects for buildings, there are fewer that have been established for infrastructure. Some work is being done on this by Building Smart, creating road and rail alignment IFCs – but this work is in its infancy.

There is no common data dictionary definition for infrastructure components, although there is some work going on in this area by Building Smart.

In general, the best solution for an open approach is to adopt existing standards and modify them for infrastructure. These include:

- Open Geospatial GML for polygons and map features.
- Land XML – for modelling nondiscrete infrastructure.
- Open Building Smart IFCs for discrete structural objects – but with great care.

Top things to consider

- Start with your end in mind.
- Be clear about your information requirements, your clients and your specialist subcontractors.
- Be clear who is delivering what information. And their roles.
- Identify the information requirements that you are fulfilling and model appropriate to those requirements. Do not over-model too early.
- Make sure you model in a geographic context and not a local or building grid context.
- A good volume model breakdown structure is key to good federation – spend time on this.
- A clear BIM Execution Plan laying these things out is essential for good BIM.
- Your first model is a survey – make sure it is captured and stored in open formats; do not use CAD formats and layers to model survey objects, rather use GML formats. CAD drawings in DWG and DGN diminish capabilities to manage data.

- Choose software carefully and ensure that results can be easily federated without major reformatting.
- Follow the BS and PAS 1192 processes and don't cut corners: the process is designed for federation and collaboration in a controlled way. Some software does this better than others.
- Create and model using best software tools but capture and manage using the principle of holding geometry and data as linked but separate. The concept of a single modelling environment rarely achieves the goals software vendors promise and often can be restrictive.
- Use 'open' data principles and refrain from proprietary formats. A mixture of GML, LandXML and IFC will cover most things.

Part II
PEOPLE

Chapter 5
Collaboration

John Eynon

5.1 Introduction

The rate of change in our world is increasing day by day. We are overloaded by information, and every day there are new must-have gadgets and gizmos. If Facebook were a nation it would be now vying with China and India for largest in the world, with a current population (active users) of over *1.5 billion*, which just shows how the technology of social networking is impacting on us all and how fast life is changing. Remember: Facebook was only founded in *2004*.

An ancient Greek would take some time and have difficulty getting up to speed with the technology that we now use every day without even thinking about it, but they would easily and immediately recognise the same modes of human behaviour: ineffective communication, anger, frustration, rage, jealousy, personal and work politics and the whole range of human behaviours that we all know so well. Some things, or to be more exact people, do not change!

Successful projects are the result of teams working successfully together. Assets, infrastructure and buildings are commissioned, conceived and built by people and are not just the result of applied technology. Our industry is all about teamwork and how people come together and work together as a team to achieve a common goal.

We work in teams every day. We regularly make and break teams. Rarely do we consider properly the implications of what we're doing; how people can work together effectively and the loss of knowledge to our organisations as people move on into new situations.

It is true that the processes, tools and technology employed will all be factors in achieving the end result, but even with BIM these are still only tools, used by people, after all. And it is this group of people, the project team, that will ultimately determine the success or failure of your project. Ignore this basic and simple fact at your peril!

Admittedly, the project team leader and their particular style of leadership are hugely influential on team success, but there is a lot of material already out there about this subject. I suggest you read some books by Jack Welch, Jim Collins, Seth Godin and Simon Sinek, to name just a few.

Our human-ness affects everything we do (of course!), but most of the time we're not thoughtfully conscious of this in the present moment, the now. You can't plan for

Construction Manager's BIM Handbook, First Edition. John Eynon.

stupidity and the vagaries of human nature, but you can take a few steps to arm yourself for the fray. While I would not pretend to be an expert in soft skills, and I've had more than my fair share of failures, getting some understanding of the dynamics of teams, how they work and some of things that make people tick can only be of help in your efforts to collaborate.

So, I want us to take a look at this in a few layers, rather like peeling an onion.

With the help of Anne Kemp and Saima Butt, in the following chapters we will look at project collaboration and styles of leadership. It is interesting to consider that this is agnostic to the technology. Whether we're using analogue systems, digital or bunches of bananas, this is about how people work together.

I think there is part of us that would like to codify everything. If only it were as simple as defining everything as a series of digital contractual transactions to complete the project. This is possible now. But I think there is a human aspect to all these information transactions, and this is where how we work, collaborate and succeed as teams becomes critical.

5.2 Changing times

As I have alluded to elsewhere already, we are living in challenging times, and never more so than at the moment. The construction industry is still emerging from its deepest recession for many years, something unknown to the younger generation although sadly veterans have seen it all before. The recovery is going to be a very long haul. It will be several years before the industry reaches pre-recession activity levels and by that time our industry could be very different.

Technology and BIM in particular will have a big say in the future of the industry, as will climate change, generational change, the depletion of natural resources, training and education challenges and the skills gap, changing practices in procurement and so on.

These drivers and more are the external forces, or tsunamis, which sometimes push the agendas and the people we meet every day. They are hitting us now and will continue to impact over the next decade and their effects will trickle down to the grass roots of our industry, changing the way we work, the resources we use, the buildings we construct and the environment we leave behind for the next generation.

On a human level it can get personal too. It might be as simple as the fact that the person you're dealing with didn't sleep well last night, or is worried about their sick child or relative, or next month's mortgage payment. We all carry our agendas behind our masks, which dictate our actions.

These external forces filter down into our daily situations, sometimes determining the positions or stances that ourselves or others or our businesses take up in situations and meetings, or influencing the decisions that are made (Figure 5.1). A simple example is when the fees or the profits have run out, meaning that whatever happens, a particular organisation cannot commit any more resources to a task – whatever you do.

There is also another lens that complicates this picture even more. Our own personality type: how we prefer to think, feel, act and communicate with others. This then

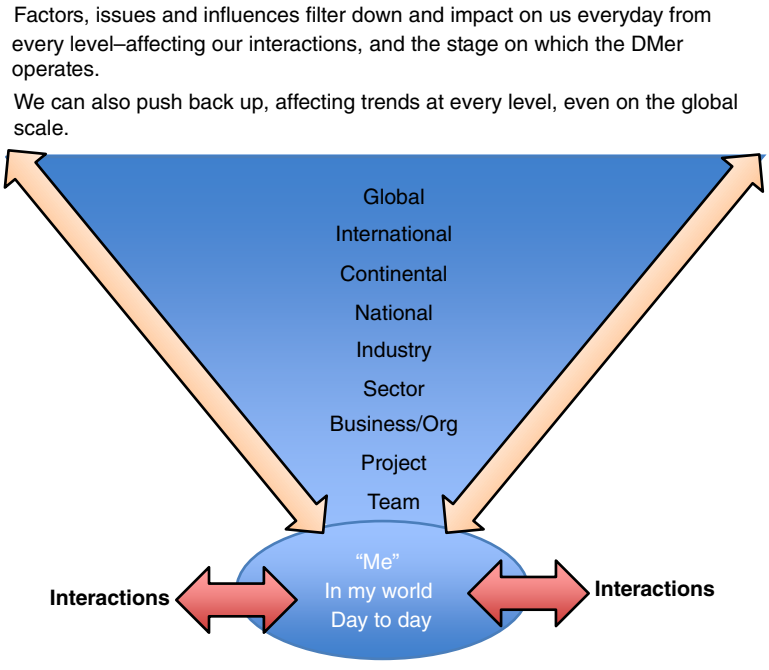


Figure 5.1 Factors, issues and influences filter down and impact on us every day from every level – affecting our interactions and the stage on which the DMer operates. We can also push back up, affecting trends at every level – even on the global scale.

is multiplied by the profiles of the people who we engage with. The possibilities are endless and life, as we all know, is never as simple as it seems!

Many factors drive people's agendas and things are rarely what they seem on the surface.

5.3 Tribes

Let's think a little about our tribes.

'May you live in interesting times', as the Chinese say. Our industry potentially will change more in the next 10 years than the last 100, through the impact of technology both on- and offsite. The long-term effects will lead to more integration and collaboration, a convergence and blurring of some roles, and potentially the end of some others, and the creation of new disciplines. Could this be an example of Darwinian evolution in action? Certainly the way we have worked in the past will no longer serve us in the truly BIM data-rich collaborative environments.

So can designers and constructors really integrate? Or, to put it another way … If constructors are from Mars, are designers from Venus?

I think they can work together successfully, but it is rather like porcupines making love – it has to be executed very carefully!

The industry in which we work is traditionally adversarial. Even with partnering, frameworks and supposedly integrated processes, we can still easily revert to type and retreat into our corners when feeling threatened and given the opportunity.

We can be more concerned about protecting our own positions rather than working together – sometimes to the detriment of the projects we're delivering and our customers. These silos or positions can be based on contractual boundaries but also influenced by our tribal background. Interestingly, even within teams these sorts of dynamics can undermine collaboration and make the team ineffective – a sort of implosion, eaten away from the inside by personal agendas.

5.4 What makes a tribe?

Tribes have their own values, culture and history. They have their own particular mindset and mentalities. This can extend to their particular use of language, and even kinds of words. There is something distinctive about a tribe, and also being part of that tribe.

A tribe is not necessarily an organisation or an institution – perhaps more a cross between a family and a movement. It embodies a sense of belonging – both a personal and a tribal identity. It is a fusion of history, culture, education and life.

So I would like to posit that there are two main tribes in our industry, with some subsets, and these contribute to some of the basic drivers that determine how we work together (or not!): Design and Construct.

If you want to think about the subtribes and their mentalities then consider:

- Do architects think they're better because they have the ideas?
- Do QSs think they're better because they control the money?
- Do engineers think they're superior because they make it stand up and buildable?
- Are bridge engineers quietly smug because they design massive complex structures?
- Are builders really the best because they turn all those drawings into actual physical reality?
- Are the specialist subcontractors the real kings of the process because they provide the real expertise to make it all work?

And so on …

Each tribe has its own culture, view on life and perceptions of the other tribes, and even language terminology.

So let's introduce the two main tribes; first …

5.4.1 The Tribe of Design

The hallmarks of this tribe are creativity, visual awareness and intuition, and they are iterative in terms of process. Designers are prone to be more ambiguous, thinking more about possibilities, options and ideas than dealing in certainties. After all, they're the creative types! They view a line on a drawing as something that could change, it has potential, possibilities (Figure 5.2).

Contrast this with …

Figure 5.2 The Tribe of Design.

5.4.2 The Tribe of Construct

This tribe thinks in linear, practical, cost-driven ways. They are much more concerned with deadlines, certainties, the facts and the bottom line.

Constructors deal in certainty. After all, they have to build the project to an agreed time and cost. They are the pragmatic, practical people, who work to a programme and build with relentless logic, steadily, step by step. They view a line on a drawing as something fixed, known and to be built (Figure 5.3).

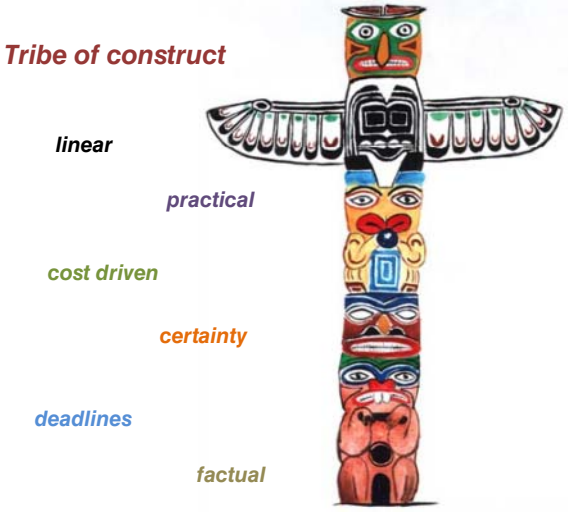


Figure 5.3 The Tribe of Construct.

5.5 Processes in conflict

As discussed above, the process for the Tribe of Design could be illustrated by a loosely coiled spring, an iterative loopy design process hopefully going in the right direction, but sometimes not. The design process can get sidetracked, disappearing up cul-de-sacs only to go forward again before closing in on the final solution (Figure 5.4).

In contrast, the tribe of construct uses a linear, logical, practical process, step by step methodically assembling the building.

It is no understatement to say that these processes are fundamentally in conflict, effectively at war with each other. In addition, designers design holistically, they design the project as a whole, everything considered together. In contrast, most projects are procured and built through subcontract packages, dividing the project down into the component or element specialist subcontracts.

In terms of these two main tribes, we could even be talking about different kinds of people. Naturally people are drawn to different aspects and different roles in the industry. These factors only serve to add to the divide and the lack of mutual comprehension.

This is why and where BIM and Design Management become relevant to bridging the divide. To reinterpret an earlier remark, if designers speak Venusian, and contractors speak Martian, then BIM and design managers need to speak both!

The management of the processes and tools they use ensures that the design iterations produce the right information at the right time to feed the linear practical construction process, which must not be delayed and must deliver on time, on budget, and to the required quality.

However, here, we are as leaders or collaborators in the process are sitting on an uncomfortable fence between the two tribes and the two processes that are in

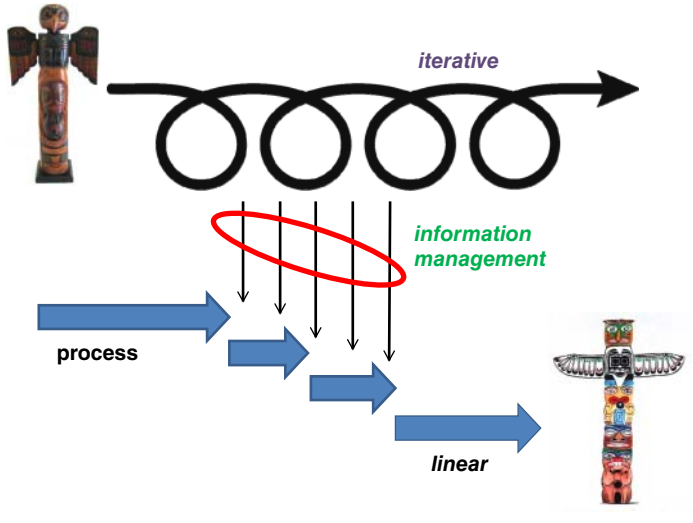


Figure 5.4 Processes in conflict.

fundamental conflict. Even the thought processes are totally different. This divide is the result of years of training, ingrained cultural understandings, prejudices and predilections that affect the way we work, make decisions and interact with each other in the team.

5.6 Transition

However, the tide has turned and is now running up the beach. Some are not aware of the immensity of the tide of change that will sweep across the industry leaving virtually nothing untouched. The past recession has brought things into sharp focus; the drive for efficiency, costs reductions, technology, zero carbon, climate change, resources, demography, skills, training, equality and diversity are all slowly tightening their grip.

Our industry is under huge pressures to change. Under the pressure of this onslaught, I think the tribes are in transition. They have been for a while and the process will begin to accelerate exponentially. There will be vested interests that try to maintain the status quo of the current positions for their own reasons, but I suspect the force for change will in time become irresistible, affecting disciplines, education and eventually institutions.

Undoubtedly there is a lot of navel gazing going on in the industry at the moment and also in the various disciplines. Roles and training are under scrutiny. Particularly at a time when the costs of education are soaring and graduate unemployment is on the increase. The relevance of graduate training to businesses and industry is seriously being questioned. Students question whether they are obtaining value for money in the training they receive, particularly as they will be in debt most of their working lives to pay for it. Practitioners question the quality of graduates being produced and whether they are fit to practise as professionals.

At the same time the industry is under greater pressure than ever to reduce costs, invest and innovate, maintain competitive edge and simply stay in business.

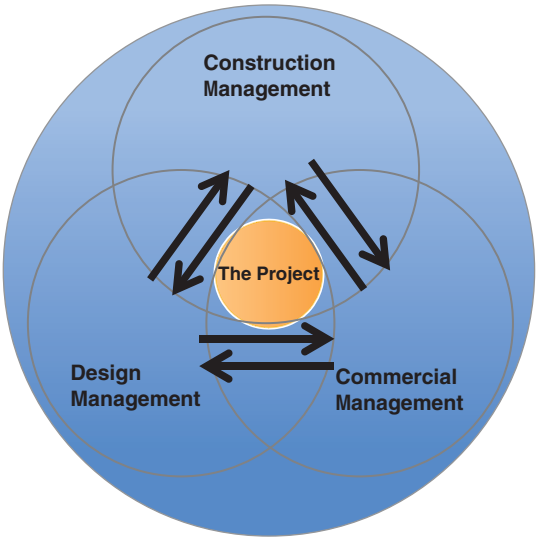
These external, global societal factors – plus the tribal background – provide a backdrop to the project environment, the roles that people play and the positions that people can take up in conflict, negotiating teamwork and leadership positions.

5.7 One tribe

I just wonder whether the time has come for us all in the industry to think of ourselves as one tribe. I couldn't come up with a mind blowing name, but …

5.7.1 The Tribe of Solutions

Whether architect, engineer, contractor, subcontractor, we all contribute to making and delivering solutions for our customers. We need each other. We need to work together and ultimately with every project our fates are inextricably intertwined. We succeed or fail together.



The Perfect project – all disciplines and tribes working together holistically for the good of the Customer and the Project – Connect, Integrate, Communicate, Innovate, Collaborate – Information Management is intrinsically connected and makes it all possible.

Figure 5.5 The perfect project – all disciplines and tribes working together holistically for the good of the customer and the project – connect, integrate, communicate, innovate, collaborate – information management is intrinsically connected and makes it all possible.

We need to think of ourselves as one tribe and value the distinctive contribution of each individual. On the perfect project all the tribes work together, collaborate and exchange information (Figure 5.5).

However, there is a major problem for each of us in our DNA. It takes years of training to eradicate the gene that causes these problems and even then the cure may not be successful!

5.8 It's in the DNA

The process begins at our birth – that is our professional 'birth'.

Our tribal culture starts in the colleges and universities where we complete our qualifications and degrees, and on the sites where we train future generations.

Isn't it ironic that we train our future professionals in tribal silos, reinforcing the generations of history and tribal culture? Upon completion of their courses, graduates are released into the world 'to go forth and integrate!' – work together as one team, with common goals and understanding. It is as if this will happen suddenly and work by some mysterious process.

As we have seen, tribal understandings can act as filters on our interaction, and we haven't even considered basic personality issues yet! Even when, in recent examples

of industry best practice, teams have integrated, collaborated and communicated successfully, they can then revert to adversarial type on their next project with no apparent difficulty.

Clearly something does need to change. There are many reasons why, but I think the forces for change, both external and internal to the industry, are conspiring and converging and within a generation will force us to adopt new ways of working, changing education systems and perhaps even institutional structures. BIM is a huge opportunity for the industry to move forward and is one of the main drivers combined with the economic drivers of society.

Within the disciplines, this isn't just about architects. I attended a conference for specialist engineers a few years ago and I was amazed to learn that a lot of the issues discussed were just the same as the discussions raging in architectural circles, such as their position and standing in the industry, relationships between designers and constructors, the skills gap, relevance of training to practice and graduate unemployment. Similarly, from postings on the internet recently it can be seen that surveyors too are undergoing some heart-searching about their role, future in the industry and their institutions and groupings.

A tribal understanding of our industry and these external forces provides a few layers or filters on our interactions. The dynamics of businesses, our teams and our own personalities and preferences are additional factors affecting how we work together.

5.9 Teamthink

It has always fascinated me how some project teams composed of talented individuals can be outperformed by a team of supposedly lesser-able people who work together better as a team and achieve outstanding success.

To use a sporting analogy, in 1988 Wimbledon won English football's FA Cup at the expense of the supposedly superior Liverpool – a classic example of a collective team performance winning over individual talent.

Leadership would be a factor here, and certainly I've worked with great team leaders in the past. Leaders who know how to get the best out of the team bring people together in a common purpose and also sometimes have just the right words for the right moment and lead the team to achieve outstanding results in the process. On one project there was a Project Manager who without doubt was the best I've ever worked with – the project was a resounding success, and also very profitable, and to a man I think we would have walked through fire if he'd asked us to!

However, the composition of teams isn't given much deliberate thought either, other than whoever happens to be available for a particular role at a particular time. Perhaps more thought could be given to how we put teams together, not only balancing skills, experience and expertise – but also balancing the fit of people to give the team the best possible start and the collective tools for the job ahead. Where this isn't possible, a little more awareness around this subject will help teams to collectively work together through a mutual understanding of where problems could arise.

We desperately need to have more awareness of who we are as people and how this colours our daily working relationships.

5.10 Individual and team dynamics

While we have looked at various influences and agendas, there is of course just the factor of how we are as people, how we prefer to work, communicate and engage with others.

So I would like to touch upon psychometrics and personality type. There are many profiling model systems out there, probably most notably Myers Briggs, Belbin and KAI – to name just a few. We have included a few ideas for further reading in the bibliography, but have tried to avoid using the terminology of any particular system and take a more neutral approach.

But that said, clearly people come in different flavours. For instance:

- Those that like to be more ordered and organised, use lists and schedules.
- Those that are more gregarious and prefer to work things out with others.
- By contrast, those that are perhaps more withdrawn and prefer to process and think things through individually before sharing their ideas.
- Creative, ideas types that are not so practical in their approach.

Details on various models can found here:

- Myers Briggs: http://www.myersbriggs.org
- Belbin: http://www.belbin.com
- Keirsey: http://www.keirsey.com.

However, a few words of warning.

I am sure you will agree that people are pretty complicated. Sometimes what you see is not what you necessarily get, and the danger with modelling behaviours is that this can quickly descend into stereotyping. People do not fit in boxes as much we think they do, nor do they behave according to the labels we assign them. I prefer to think of these systems as indicators of behaviour but they are no more than that. Nothing is rigid. Be ready to be surprised, as the range of human behaviour is far wider than we can sometimes imagine!

Personality types, or indicators of behaviour, only identify preferences in the way people *prefer* to behave. This doesn't rule out their behaving outside of their 'type' in certain situations, in response to pressures or other agendas – because that's what people do!

Also, be aware that as people grow and change through their lives the subtleties of their personality can change also. Major life events can have a significant impact upon our preferences; for example, bereavement, marriage, divorce, redundancy and so on. I know from my own experience having completed Myers Briggs profiles about 12 years apart. Some of my preferences had moved across boundaries into different categories. In those 12 years I had experienced some significant changes both at work and at home – and they had had a significant effect.

There is another aspect in team and project life, which I want to mention in passing.

5.11 Fun and joy

(Enjoyment, amusement or light hearted pleasure. A feeling of great pleasure or happiness – *Oxford English Dictionary*.)

As much as our human-ness affects what we do and how we do it, I think we need to derive some pleasure, joy, fun – if you will – in the process and the outcome. The best teams for all the ups and downs of working relationships actually *enjoy* working together. Yes there'll be some banter, but underneath there will be mutual respect, openness and integrity.

The cogs will be oiled by some social sessions, whether this is at the pub, meals out or paintballing. Just a thought, but has it all suddenly become very serious? Of course the stakes are high on any project, but it all becomes just a little easier if we can enjoy working together as well.

5.12 Know yourself

If this subject of people is of interest to you, it is worth taking a few profile tests to get to know your own indicators and also to get to know a few of the systems. It is interesting to see whether the results chime with your own perception of yourself, or provide a few surprises. With a little knowledge it becomes relatively easy to profile individuals in a rule of thumb fashion to analyse simple dynamics between people. Occasionally this has helped me understand others to help with communication and team working.

Consider the classic exchange between an introvert and an extrovert, or, say, a creative with a more logical practical type. What is happening? Different things are important to different types of people, the processing of ideas and thoughts is happening differently – for the extrovert it is more externally, while the introvert will tend to say much less but the eventual statement will be more considered and concise.

So how well do you know yourself and what is going on around you?

5.13 Values

Who are you? What do you stand for? The DMer stands in that uncomfortable zone between designer and constructor – and many other stakeholders for that matter. A major part of the role is building successful relationships that will last the lifetime of the project and perhaps beyond. This is critical to your success. Values like respect, trust, integrity, transparency, honesty spring to my mind. This doesn't mean agreeing with everyone or never saying no, nor giving away sensitive information or the crown jewels, but it does mean being the same person to everyone and performing your role with integrity.

Over a project's duration there will be give and take, ebb and flow, in all relationships. Sometimes you will need help, sometimes other members of the team will need your help. The best projects work without having to refer to the letter of the contract. This is where the whole team comes together and collaborates, crossing the boundaries

of their respective businesses, and their roles, to achieve the project goals – effective relationships in action. Everyone benefits from a successful project – likewise everyone shares the pain of failure in some way.

So what are your values? What is important to you? If you know yourself, your ability to be authentic and build lasting and productive relationships will increase, benefitting yourself, your team, your project and adding value to your business.

And finally for this section

While process, tools and technology are the cogs of BIM, we forget that the people using them are not robots nor are they machines. This human-ness factor colours all our interactions and provides many layers of meaning, agendas and interpretations. It affects everything we do: how we communicate, how we work together or, in the final analysis, not. This aspect is so important and yet so frequently overlooked. It is the oil that keeps the wheels turning efficiently and smoothly.

We need to learn to understand how people interact and relate. Understanding ourselves and what we bring to the project, with our own distinctive traits and gifting, is also a key factor. Anne and Saima explore this in more detail in the following chapters.

Chapter 6

Collaborative Working

The Art of Thinking Together

Anne Kemp

> 'We don't know how to think or talk together in a way that summons up our own deeply held common sense, wisdom or potential …'.
>
> (Issacs, 1999: p. 2)

6.1 Introduction

'Collaborative working' seems to have joined 'BIM' on the hyped-up stage of buzzwords. A shame given the immense importance behind the words.

Suffice to say, collaborative working seems to be both a panacea – and the biggest headache – for the architecture, engineering and construction (AEC) industry (and I include the infrastructure industry within this categorisation). To many (as intimated in the Construction 2025 report of HM Government, 2013) it should be 'common sense', but it seems frustratingly difficult to embed and sustain within the industry's ethos and culture. Instead, our industry continues to have the reputation for being adversarial, silo-ed, and slow to change.

So, why should that be? And what can we do about it?

In this chapter, we are going to explore the issues and the hang-ups and hopefully identify some of the missing pieces. We will scan the landscape of this world of ours, starting with ourselves as individuals, the teams and organisations we inhabit, and the leadership which we so often look to others to provide without realising that iat can come from ourselves. And then we will wonder why we hesitate to be more aaware of ourselves and each other as human beings, why we are shy of bringing all of ourselves into the workplace – and why this could transform the way we work and what we can achieve.

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Figure 6.1 Word cloud of key phrases associated with collaborative working (Kemp, 2014).

I've been lucky enough to have spent the last few years doing an MSc in Coaching and Behavioural Change – and my research has explored how to embed collaborative working across the construction industry. I will draw on this research to provide examples, particularly from the interviews, and to share with you my key findings.

Finally, I suggest possible ways to develop the art of collaborating together.

6.2 The way into the problem: a systemic approach

Collaborative working is tough. This is not about cosy, complacent relationships with no disagreements. This is about cultivating the very best and challenging thinking, of going to the limits of a relationship in arguing and contesting, exploring and testing, listening and reflecting. This is an environment of contrast – of action and reflection, of safety and of risk, of trials and of reward. But it should also be a culture of warmth and respect, of humility and pride, of sensitivity and firmness.

> … Contracts alone do not deliver improved performance or greater efficiency … [this] can be made by aligning behaviours and commercial arrangements throughout the supply chain (HM Treasury and Infrastructure UK, 2013: p. 20).

The challenge we have is that people will view the problem with differing perspectives – reflecting their experience, circumstance and skill. Providing a framework

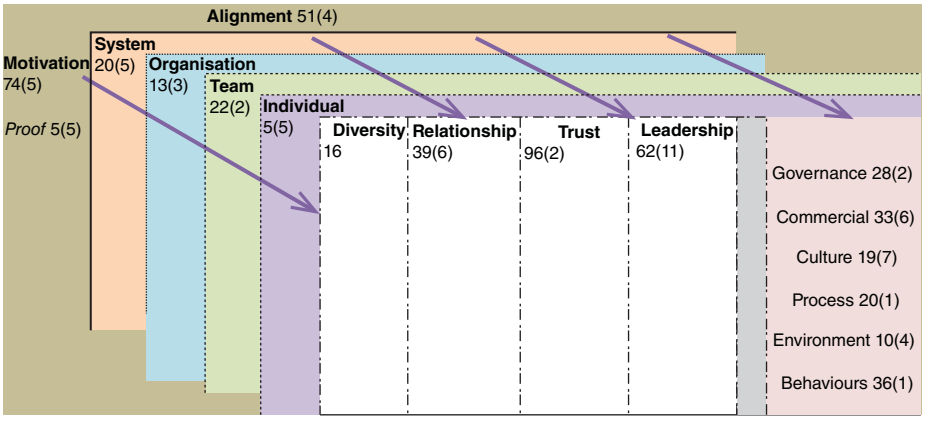


Figure 6.2 A systemic, conceptual framework (Kemp, 2014).

that allows a wider perspective that can take account of these differences allows us to find a way into the problem, and to start to develop a common language (see Figure 6.2).

In my research, it became clear that there was confusion over to how to frame the problem. A number of models suggest that if you don't get a balanced approach, and focus too much on any particular issue, you are likely to encounter instability and resistance to change. The analogy of a three-legged stool is often made to emphasise the need for balance and adoption of an integrated, holistic approach. Neglect commercials, and the stool will wobble; neglect governance, and problems will occur; ignore people, and the stool will likely fall over. This holistic framework identifies that collaborative working occurs at a number of levels throughout the system – at individual, team, organisational, and at the system level. There are a number of elements that affect the running of the system – shown in the right-hand column of Figure 6.2. What emerged from the research was that the key drivers for successful collaborative working seem to be diversity, relationships, trust and leadership. However, what was very clear is that if alignment does not occur across the system – at all levels and across all the key elements – and if there is not clear motivation provided to focus energy on the drivers for collaborative working, then any efforts to embed such behaviours are likely to be short lived.

The beauty of a holistic framework of this kind is that it provides a broader perspective and can be used to reflect and discuss the possible blockers that may be causing trouble at any given time or at any given level in the system. So, for instance, it could be used as a tool for an individual, for a team, for an organisation or across a programme, allowing focus in the right place to redress the balance and apply the appropriate interventions. In the example above, the framework has been used to monitor the number of times, during interview, that people mentioned that particular component, first as something that is required for collaborative working and second as a barrier. While not intended to be prescriptive, it can give you a useful barometer of where trouble is brewing.

Within this context, and within the world of BIM, I would contest that, at the present time, we have not focused enough, as yet, on *people* and the behaviours we need to support BIM working. So what should we expect?

Some of the answers lie in BS11000: Collaborative Business Relationships (2010), which offers a Relationship Management Plan with the intent of contracting for trust from the start:

> The right business environment to support relationships needs to encourage openness, honesty, responsiveness, commitment, performance, fairness, information sharing, giving early warnings, and doing more than just the minimum required to reach goals.
>
> (BS11000-1:2010:37)

Some of the diagnostics of competencies and behaviours are provided in Table 6.1.

6.3 The missing pieces to instil collaborative working

So it seems within our reach to characterise collaborative working. But the problem remains as to how and why an individual or a team should respond and behave as specified. What are the incentives? Can we really expect people to just 'do' collaborative working – does it not require at every level a clear motivation to shift to a new way of behaving – and sticking with it? And won't this require practice?

I have a real concern about the current trend in the industry to measure for competencies as part of the bidding process and at start-up workshops without following on with appropriate training and support. The old adage 'practise makes perfect' rings true for me here – and by setting this expectation this could add an element of pragmatism – of tolerance and forgiveness that getting this right takes time and we can all learn from our mistakes. And while people may have supposed 'competence', do we seriously expect them to somehow conjure up the willpower and the incentive to consistently apply it? Perhaps it feels dangerous to do so?

One of the difficulties I believe we face is identifying what are issues rather than symptoms – and understanding that these may well change with different circumstances. This is where I hope the framework can help. A simple way to distinguish the two is to consider issues as the things that, if altered, close the gap between the actual and desired states, while symptoms are signals that some change may be needed to avoid further problems. Is it possible that much of the work seen across the industry to embed collaborative working is aimed at the symptoms of it not working rather than the issues? So, looking at the framework in a particular context, I may identify broken relationships, broken trust and/or poor behaviours as symptoms. Leadership, alignment and motivation would be significant elements that could help close that gap. I would argue that, at the moment, alignment and motivation need attention, for if these could be altered then better relationships, better trust and better behaviours would more easily develop and more readily be sustained. If not, then any improvements in the symptoms are likely to be undermined and be short lived. Misalignment and poor motivation would persist.

Table 6.1 Critical competencies and behaviours (based on Kemp, 2014).

Critical behaviours from BS11000-1:2010:27 Annex C	Collaborative (Gray, 1989)	Individual Competencies (Bower *et al.*, 2012: p. 2328)	Critical behaviours for an Intelligent Client (Bower *et al.*, 2012)
• Listen effectively, respecting opinions of others	• Parties positioned as joint problem solvers	• Actively listen and frequently seek the opinions and contributions of others • Ask for assistance when needed • Respond positively to the requests of others for help and support	• Credible – technically respected but admits what they don't know
• Information Sharing, constructive questioning, open and honest feedback	• Joint search used to determine facts	• Involve others and share appropriate information, knowledge and outcomes in a timely fashion • Encourage others to do the same	• Information management
• Recognise the objectives of all parties and seek ways to help maximise their achievement • Accommodate needs of all stakeholders in order to deliver shared goals	• Issues can be identified before positions crystallise	• Actively seek to understand the motive, values and attitudes of others	• Able to challenge changes from above • Establishes correct measurement/metrics/targets for success

(*continued overleaf*)

Table 6.1 (*continued*)

Critical behaviours from BS11000-1:2010:27 Annex C	Collaborative (Gray, 1989)	Individual Competencies (Bower *et al.*, 2012: p. 2328)	Critical behaviours for an Intelligent Client (Bower *et al.*, 2012)
• Communicate effectively, consistently, openly, honestly and in a responsive manner	• Characterised by search for underlying interests	• Demonstrate strong interpersonal skills and engage with others effectively	• Has high awareness and ability to manage and lead on both the cultural and business issues – not just one dimension
• Negotiate without taking advantage • Consider possible future implications of current issues	• Characterised by interest-based bargaining • Broadens field of options • Authority for decisions rests with parties		• Resolute, has conviction, determination, backbone • Rewards/incentivises supply chain • Timely decision making
• Appreciate and respect differences in cultures: be proactive to resolve potential difficulties and overcome barriers	• Face-to-face discussions encouraged among all parties • Characterised by respect and application of reason	• Develop and maintain networks of working relationships • Comfortably work with and as a part of different groups (internal, external, permanent, temporary, cross-functional and cross discipline)	• Able to bridge interfaces between organisations • Flexible
• Learn from and share experience and setbacks		• Identify areas for resource sharing and opportunities to collaborate or partner with others both internally and externally	

Table 6.1 (*continued*)

• Understand and support others in the achievement of their own goals • Establish joint needs/outcomes; deliver against objectives; act in best interest of joint effort • Balance risk and reward when considering innovative solutions and future possibilities	• Outcome must be satisfactory to all parties • Seeks workable options • Yields resolution of integrating interests		• Consistent attitude towards others • Ensure project supersedes individual stakeholders • Understand why doing processes – not just for the sake of it
• Address short term imperatives without losing sight of long term objectives; learn from experience and embrace changes			• Establish project purpose, principles, roles and tasks before the detail
• Constructive/flexible attitudes to change; facilitate creativity in others by encouraging challenge/new ideas			• Advocates on behalf of team – establishes no blame culture
• Demonstrate respect/consideration for all partners; consider impact of actions upon others • Aim to create mutual understanding but hold people to account for unacceptable behaviour	• Promotes trust and positive relationships	• Positive regard, authenticity, empathy, responsibility, equanimity, openness (Willcock, 2013: p. 46)	• Lead from psychological stance of joint interest working (trustworthy, open and honest)

Perhaps this conceptual framework, given its holistic, systemic approach, could allow particular, focused approaches and tools to be set in context and allow people to be mindful of other factors at play. This could then guide a more flexible and more lasting programme of adjustment and support.

6.4 Instigating change

How do we make people feel 'safe' to work collaboratively? Oddly, this was a word entirely missing from the interviews I've conducted as part of my research, except in the context of health and safety. Yet it is one of the key drivers to sharing data within Level 2, and I would argue Level 3, BIM. And it underpins how one encourages openness and trust Table 6.2.

The problem is that, psychologically, by our very nature, if a change is imposed on us we are likely to react and resist in equal measure. We want to preserve our values and our identity … and change within the context of collaborative working very often challenges our identity, since our identity is often tied up in our sense of belonging to a particular team. We are a herd species – we like to belong to a 'tribe'. And crossing boundaries, or even getting rid of those boundaries, is particularly threatening. Why else do we feel what can be an intense loyalty to our discipline, our project team, our department, our company? And an inclination to work in silos? This is where we feel we belong – it *feels* safe. How can we make it feel safe to cross those boundaries, to share common goals, language, information and knowledge. How can we think together and make better decisions?

Table 6.2 Examples of responses around openness and trust (Kemp, 2014).

Interviewee S	Interviewee J	Interviewee R
… Trust is not an emotional issue – it's practical – about competence, consistency and openness. Thought about that a long time – often use that phrase. In a sense you can have most lovely cuddly relationship, but if they are not competent, consistent and open, you can't trust them. Incredibly pragmatic thing, trust.	Trust is right at the top. Got to be open. Trust is more a human condition I think, we've all got our ways of approaching … with trust … you won't get a collaborative contract delivering the goods unless there is a complete trust.	Trust. How you build that trust is the key. I think that nearly everything else leads to creating that trusting relationship. Whether it be information, behaviours, collocation, scope clearing or whatever it is or developing those pieces. It all comes back to trust. If you don't have great, trusting relationship at all levels – I would put that down as my number one.

If we are saying that by *imposing* change, we are setting ourselves up to fail, how would it go if, instead of a top-down approach, we allowed more autonomy and choice in developing collaborative working?

6.5 Looking to the individual

> 'The starting point for this is to focus on ourselves first.'
>
> (Willcock, 2013: p. 56).

Change comes from within. Hard though it can be, if we have got stuck in any relationship, the one thing we *can* influence and *do* something about is our own actions, our own attitudes, and how we project ourselves to others. By becoming more aware of ourselves, and realising that we can *choose* how we respond to others – whether we react to a comment, or whether we listen more deeply and seek to understand someone else's perspective before jumping in – we, as individuals, can start to shift the overall behaviour around us – leading by example, and being more mindful of how we influence those around us. Self-awareness is the first step – developing mindfulness of the wider community that you inhabit both at work and at home, and being aware of how you interact and impact your team, your department, your organisation, the project and how this may differ with what happens within your family, your circle of friends and your local community. *This* can be a real game-changer. Are you wholly present at work or do you leave a part of yourself at home? If so, *why*? Could it be that part of you actually could have something very valuable to offer in the workplace? What are you assuming that stops you doing that?

6.6 Turning to leadership: and the energy to empower individuals …

In his book, *Collaborating for Results*, Willcock identifies that leadership is about providing the right kind of energy to stimulate and motivate people, and Table 6.3 provides a summary of these energies that links back usefully to the overall conceptual framework.

Transformational leaders encourage their followers to pursue incentives that are not merely 'extrinsic rewards', but are offers in terms of values and vision. In this way they are less likely to be demotivated, and more likely self-directing and self-reinforcing (Sheldon *et al*., 2003: p. 368). Heifetz's (1994) *Adaptive Leadership* provides useful pointers to the appropriate style of leadership.

6.7 … and the responsibility of teams

> 'The concept of "shared leadership" … leadership is not the sole preserve of those occupying formal leadership roles, but also emerges when people

Table 6.3 Energies to stimulate and motivate collaborative working (Kemp, 2014 derived from Willcock 2013: p. 165).

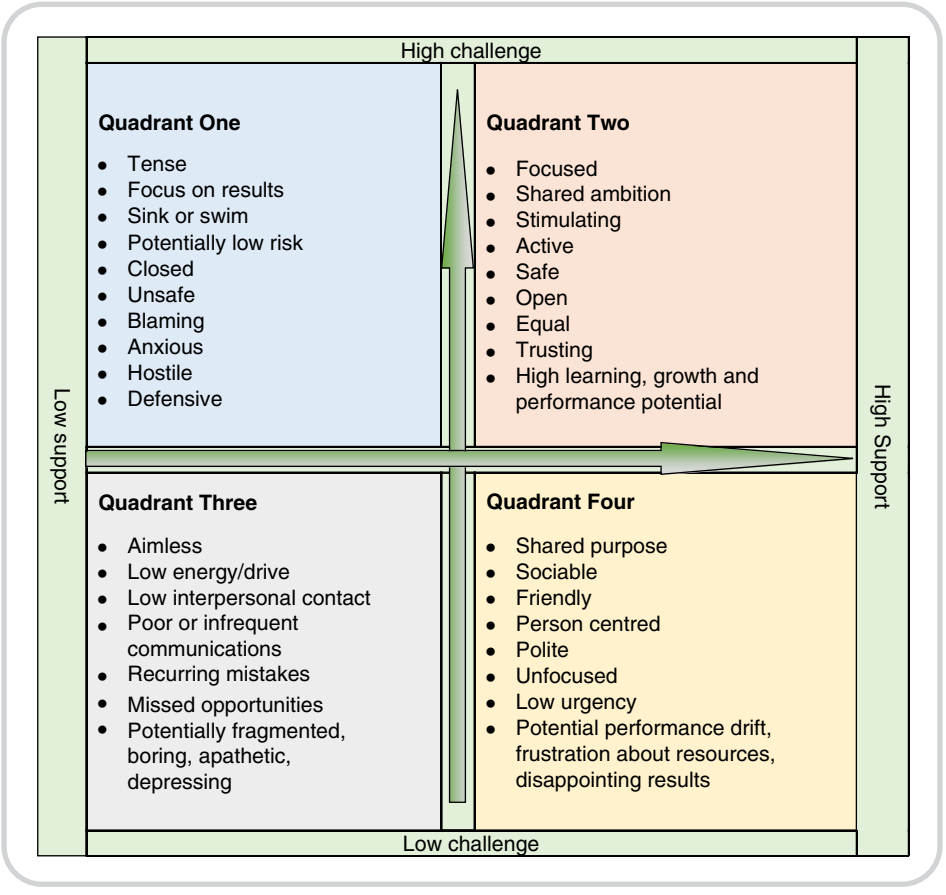
Cognitive	Providing common purpose, rationale and ongoing narrative to create shared context for collaboration.
Behavioural	Developing as 'Open Teams' and role modelling collaboration. Leaders need to step into the organisation and show commitment to that way of working.
Emotional	Creating a safe emotional environment for collaborative working, being mindful of differing needs and stages of relationship development.
Situational	Providing a framework of values and processes that support enquiry and collaborative dialogue throughout the organisation.

> work together effectively … [this has] a particularly powerful effect on the motivation, self-confidence, self efficacy, or performance [of staff].' (Alimo-Metcalfe and Alban-Metcalfe, 2011: p. 8).

I am fascinated by the behaviour of teams. The unspoken rules. The peer pressure. Following the leader. Group think. Contrasting with the way it feels to be part of a collaborative and open team, project or organisation. Because too much identification with a team – and being overly protective of its identity – actually stands in the way of wider collaboration; it needs individuals and teams that are self-aware, responsive and adaptable to the mindsets of others. Having been part of an experiment to explore group dynamics during an MSc on behavioural change, I've come to more fully appreciate how powerful the learning can be within a group. The group can act as a mirror on yourself, there is no place to hide, and together you can challenge and support each other – in understanding, in evaluating and in making decisions. This ability is important in adapting to change, in improving performance and in supporting innovative thinking. But getting the right balance between challenge and support is vital – too much challenge and defensive, closed behaviours develop, too much support and the team can become complacent and slack. Maintaining the right tension in the system – to hone the thinking, alertness and responsiveness of individuals to the wider challenges of the system as a whole – is an important premise that Willcock develops through his challenge and support model (Table 6.4).

An important aspect of this is diversity. Too often we focus on gender, race, age and ethnicity, rather than on the subtleties behind this – 'differences in perspectives, habits of mind, and core assumptions' (Goffee and Jones, 2013). This casts us back to my concern about screening for collaborative 'competence'. Respecting and honouring differences in opinion and different ways of thinking, while being able to have that difficult conversation and that uncomfortable dialogue, is something that as an industry we have to get better at. And this is where feeling safe and supported to do this – within your team, within your organisation, and on the projects you are working for – is such an important aspect to enabling collaborative working. Goffee and Jones (2013: p. 7)

Table 6.4 Derived from Willcock's challenge and support model (2013: p. 47).



focus on 'organic solidarity', where people are comfortable, and indeed think it is important to be themselves at work, instead of working within a culture of conformity where even the leaders don't feel they can truly say what they think.

6.8 Walking the talk

> [Leaders] need to acknowledge the systemic nature of relationships … If the senior teams cannot work effectively together, this will frustrate even the best efforts to develop … collaborative relationships elsewhere … there will be an invisible influence. The parallel process echoes through the emotional fabric of the organisation, affecting decisions and actions at all levels. (Willcock, 2013: p. 163.)

It is striking that authenticity is so fundamental to sustaining lasting and transparent relationships, whether that be at an individual level, between teams, or between

organisations. One may pass the competency test, but if you do not display consistency, regardless of what is happening around you, then sustained change is unlikely to follow:

> A competency framework [is] like a piece of music, a diagrammetric representation of the melody. It is only in the arrangement, playing and performance … that the piece truly comes to life. (Bolden and Gosling, 2006: from Alimo-Metcalfe and Alban-Metcalfe 2011: p. 11.)

6.9 The energy within

What kept recurring in my research was the energy needed to sustain collaborative working through motivation and alignment. If it is true, as discussed above, that to sustain motivation it must be intrinsic rather than extrinsic, this has important implications for how we tune the system overall. This relates to the industry's desire to move to longer term outcomes of whole life, resilience and integration across the whole of the built environment. Perhaps focusing and providing clear motivation around this throughout our organisations will help to get a better gearing of the system overall, and give us a far more powerful source of sustained energy to support the shift to collaborative working. In interviews, as seen in Table 6.5, where this motivation is misaligned – with differing values, expectations, goals – it was cited as a key feature in the breakdown of trust and relationships.

So could intrinsic motivation be the golden thread? And does this relate to mindfulness?

> Shared meaning is much more than fulfilling your mission statement – it's about forging and maintaining powerful connections between personal and organisational values. When you do that, you foster individuality and a strong culture at the same time. (Goffee and Jones, 2013: p. 9.)

6.10 Conclusions

The findings of my research were that what appears to be missing is focus around motivation and alignment, and any work on the people aspect needs to be set within this context. This actually gives a very practical context for driving change in the levels of engagement and understanding. Perhaps we have got stuck on the definition and measurement of the symptoms, rather than going for the actual issues. If the motivation for behaving in a particular way, or striking a relationship and working on it, is clear, the impasse and the feeling of 'stuckness' may be resolved.

I conclude that any focus on how to improve trust, leadership and relationships must be underpinned by an honest appraisal about what may be out of alignment, impacting motivation and holding the system back. I would suggest that the systemic framework presented here (Figure 6.2) can be used as a tool to facilitate discussion and provide insight into what may be going on. Once identified, these issues must be surfaced, removed or explicitly addressed.

Table 6.5 Phrases referencing motivation captured from investigative interviews (Kemp, 2014).

Individual	Team	Organisation	System	
There's a 'working for me' rather than 'working for we'	Healthy opportunity to have a team goal *and* individual goal	I think the point about energy and enthusiasm is that there is lots of it out there, but it's just not channelled	Some projects absolutely that are right for collaboration – and others that are not	**Governance**
That is the biggest blocker – in all my experience of collaborative working, when it comes to the crunch, would you as a Profit and Loss (P&L) owner, be prepared to take a loss – to hit a red in your budget line for a success that fits outside of your function or even your company		Functional silos which boil down to the things that preserve your job	Nobody, *nobody* would convince me that collaboration is less efficient than traditional. That's the question to ask.	**Commercial**
Once the objective becomes personal, becomes something that is a feeling, that is how we will sustain collaborative working	Individuals looking after their own patch and not thinking of the project as a whole. It's just individuals – but it's also – and again I always blame ourselves for not structuring or setting up the motivators right. It could well be that we've got – you know – misalignment			**Culture**
Personally, because that's what they like to do, that's how they like to work	A lot of it's around the way in which we recognise and reward individuals and team			**Process**

(*continued overleaf*)

Table 6.5 Continued

Individual	Team	Organisation	System	
Acknowledging people's personal motivations for being within the whole lifecycle of a project	Motivation against 'a common enemy' and there is an item of truth in there – if there is a common subject to beat – football team to beat or external party, it works. Another analogy … a few centuries ago, the minor third – you had the devils triad … People couldn't palate that sound … But now, our ear has … become accustomed to the sound, it no longer sounds dissonant … it is about how to grow to new sounds. [Analogy of fear of unknown with collaborative working]			**Environment**
People tend to think of it in a very limited way. Perhaps in terms of skills, or in terms of just of behaviours without appreciating that they are driven by what's inside	If somebody really does have a burning desire to affect the lives of millions by creating marvellous new innovative infrastructure projects … clearly you have something to work with … you can start to get them to see that maybe they can't do that by themselves	If we don't keep reinforcing senior leaders, if change message too quickly, if stop reiterating, stop reward, stop reinforcing then that change element dies back quite quickly	If you want this to be sustainable, it's got to be an objective that touches the heart and the soul, and it's got to be bigger than your organisation	**Behaviours**
Once a group of individuals is clear about what it is they are hoping to achieve, they will work in every way, whether it's more diversity in themselves, and their style of delivery as well as within the whole team, will be motivated in order to deliver it				

This industry *should* be able to tap into a purpose that resonates for many – creating a better world. But it is no good having a great vision if authenticity and sincerity are lacking. One of the biggest misalignments is the way that governance and procurement is currently set:

> A lot of innovation and energy is dissipated by present governance and procurement.
>
> (Anonymous Interviewee in Kemp, 2014.)

It has a focus on short-term project delivery, rather than integrated outcomes and whole lifecycle and a splitting up of the supply chain into tiers.

Could the working hypothesis be that these collaborative working behaviours are not possible unless the ability to be self-aware and mindful is fostered and encouraged at individual, team and leadership level? Certainly they are difficult to instil unless the purpose and context behind particular behaviours are made clear. Relating them to the key drivers of collaborative working – relationships, trust, leadership and diversity – needs to be explicit. And the motivation each individual has to shift to these behaviours has to be addressed – competence is not sufficient. Empowering leadership at an individual level, guided by an intrinsic motivation in alignment with the system as a whole, may sound like a panacea, but it isn't a bad aspiration to start off with. Generating a culture where people want to take responsibility for their learning and development, and buy into what they are learning and practising, is vital:

> Personally, I'm always ready to learn.
>
> Although I don't always like being taught.
>
> (Winston Churchill.)

Does the AEC industry need to be braver in exposing its softer side? As one conference delegate said to me, after I presented Figure 6.3 as a conclusion to my talk:

> Anne – this is not the softer side of BIM and collaborative working – this is the hard stuff.

There seems to be a lot of emotion around this 'namby pamby' soft stuff. I wonder if this is generated from fear and defensiveness: a classic response to change. This resistance is pervasive. And it is a problem. And I do wonder whether, until we allow ourselves to be fully human and present in the workplace with respect – until self-awareness and mindfulness can be integrated into the psyche of the industry – we will continue to feed the dysfunctional behaviours that cause so much angst and frustration? Is it not possible to control and tap into our emotions?

I conclude that there is no overnight solution to collaborative working. The recommendations emerging from this research investigation (Table 6.6) provide some practical steps at a team and organisational level to instil collaborative working in the AEC industry. But the operative word is *instil* – this is a long term and gradual transformation, which requires commitment, quiet determination, resolution and persistence. But being braver about the 'softer' issues will certainly help.

Figure 6.3 A personal reflection of how collaborative working should feel (Kemp, 2014).

Table 6.6 Key Recommendations for the industry, to instil collaborative working.

Key recommendations	
Recommendation 1	Put in place sustained and supported learning and development
Recommendation 2	Develop thought leadership on the 'soft' issues
Recommendation 3	Put in place a common sense and conscience monitor
Recommendation 4	A sense of balance – try using the framework as a tool
Recommendation 5	Consider further: Alignment and motivation Group dynamics and team working Openness Leadership Mindfulness

6.11 Practical action points

On a lighter note, why don't you try taking a lead yourself in generating a collaborative environment wherever you go? Try the practical action points below to get yourself started. Oh, and by the way, if you think you have it cracked and are a natural at it, beware. If there were ever a case that 'pride comes before a fall', I suspect this is it. Mindfulness is, for me, very much a part of collaborative working – and I'm not sure you ever master that, but you can continually practise and learn.

- Experiment with listening more and deeply – without being preoccupied with what *you* want to say or do in response. This is sometimes referred to as 'active listening'.

- Be curious about other people's worlds and opinions. Where you feel you wish to disagree with someone, try stepping into their shoes and seeing their perspective. You may be surprised how it can shift your thinking.
- Think before you speak. What do you really want out of the conversation? Do you want to have a fight and win points over your opponent? Or is there something important that needs to be challenged and worked out? You may well find that the outcome is better if done in partnership, however awkward that may feel, rather than in isolation.
- And then say what you think – be authentic. Don't hide. Stand firm – gently. Take a look at *Fierce Conversations* by Susan Scott (2002) for more ideas.
- Talk about values and hopes – your own, other people's, and the values and hopes of the team, the organisation – and the projects you are working on. Do they align? If not, why not? And what could you do to help get better alignment? And if you can't, ask yourself – honestly – what you are going to do about it. Face it, don't deny it.

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Chapter 7

Leadership Choices

Saima Butt

People love being part of a compelling story, a narrative we can recount to our friends, family and acquaintances. Think of the number of times that we pass landmarks with which we have formed more than a passing association; we connect in a way that endears that project, its outcomes and its people deep in our trails of experience – these projects become part of our story and, depending on the richness of our learning, we can find ourselves either holding on to these as stories of an embattled past or being inspired to create a new vision for our next project.

An industry that still prides itself on hard-nosed pragmatism and an ever-growing requirement for rigorous processes is experiencing a progressive, and some might say uneasy, shift towards placing 'people at the heart' of what it does. Paradoxically, it is the human-doing, not the human-being that our attention continues to focus on. The behavioural competency measures now added to technical competencies have engendered an audit trail that simply reinforces this focus on what people are doing; we justify our stories to each other whether people are operating in a team-like, collaborative manner by 'measuring to manage' their behaviours.

This chapter sets out to provoke thoughts and ideas; to step up a level and look beyond people's behaviours as the means of engaging with innovation and change. We have an opportunity in our industry to catalyse an industry-wide use of innovations by evoking that one unique human factor: choice.

Motivation to want to adopt new technology is far more sustainable and therefore resilient than simply telling people that they need to/have to/should have it! Step back and recall how the massive shift in H&S culture came about through connecting the individual with what they wanted for their families and friends as they leave and return home after each working day. How much more compelling a vision that is to hold on to than just being played stories from the past and being told we have to comply with more processes.

Figure 7.1 illustrates some of the areas in which we can exercise choice in leadership: of ourselves and those around us. The challenge is to actively listen and identify with our own values and motivations and be open to sharing these in our interactions with team members. Fifteen years of coaching and facilitation of project teams across

Construction Manager's BIM Handbook, First Edition. John Eynon.

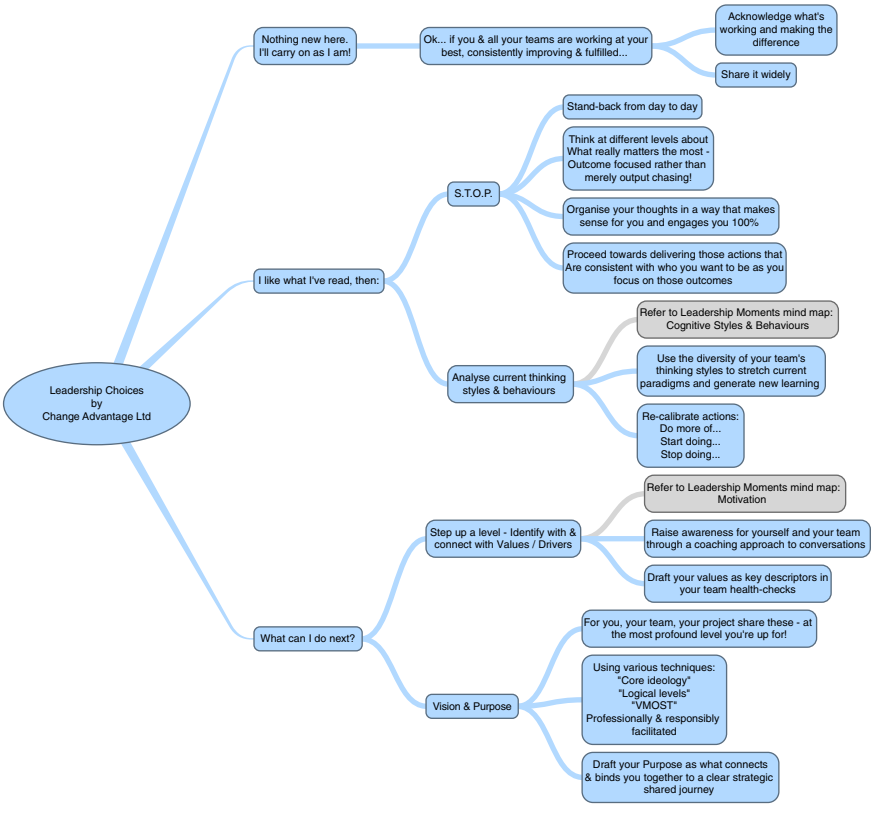

Figure 7.1 Leadership choices mindmap.

Figure 7.2 Human being to human doing. Adapted from Ferrucci, 2004.

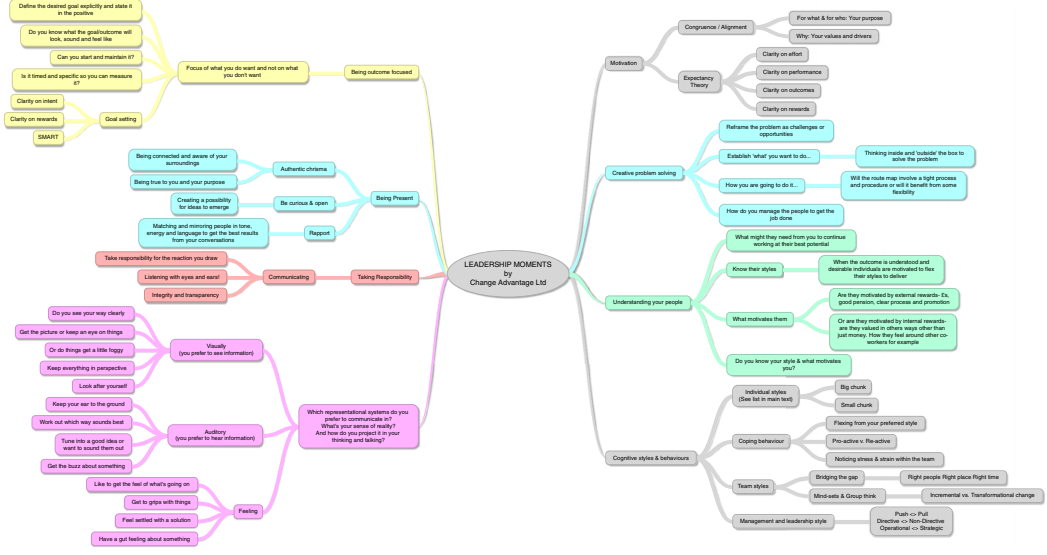

Figure 7.3 Leadership moments mindmap.

sectors within our industry highlights the innate desire that people have to respond positively to this challenge.

However, current paradigms get habitually preserved with statements like 'We're only engineers and we don't do this soft stuff' or 'Once I have clear evidence that people are working collaboratively, then I'll also be up for change!' and even 'People will only adopt these changes if they are made to through contract conditions, incentivised targets with pain/gain arrangements – at least that way we can name and shame them'.

And of course some of the most limiting beliefs come from incumbent managers who, with an underlying positive intention, nevertheless find themselves responsible for statements such as 'If we open that can of worms we'll never get this thing built – it's not broken yet so why fix it?' often backed up by 'If you tell our people too much about what's going on it'll throw them' and the most common one 'I have to behave like this at work, I don't do that sort of thing with my family'.

As far as responding to innovation, change and collaborative working: 'Well, it's all designed to control us and limit our scope to be profitable' or 'That's just a few people with vested interests looking to force change on us all' and alarmingly 'We've got on perfectly well without it before, why change now?'

Many reading the last three paragraphs might comment that such selective anecdotes aren't reflective of our industry, and anyway things are much different now compared to 15 or even 5 years ago. In fact, the quotes above are taken from workshops during the period 2013–15 and across a range of high-profile organisations and projects working in frameworks featuring partnering, collaborative or integrated team working. So what is the value in these stories? A rich opportunity to learn about what drives and motivates such behaviours by inviting people across our industry from our project teams to connect as people; as human beings first – the human doing then follows (Figure 7.2).

And that is exactly what project teams experience. When given the opportunity to richly explore themselves, their values, their motives, people do break through those limiting paradigms and connect in a way that becomes far more open to sharing and learning. From this comes the inspiration to set new visions and intent for the next project. And it is by creating this space that the opportunity comes to take on board innovations, novel collaborative tools, and to set new exacting standards for performance. These are driven with energy through a clear team motivation that goes far beyond the 'need to have to deliver'; the team and its people want to fulfil their mission by seeking out every opportunity to 'be the change they want to see'.

By working through the mind map in Figure 7.3, identify some of the choices and mindset shifts you might want to pursue – be up for those changes. Do what's consistent with upholding these principles. Have the results you are deserving of!

Reference

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Part III
PROCESS

Chapter 8

BSI B555 Roadmap

British Standards Institution

The 'BIM Wedge' has become one of the defining icons of UK BIM. Designed by Mark Bew and Mervyn Richards, it has graced many talks, presentations, conferences and publications over the last few years. This is a pivotal piece of work and has been used to set out the supporting documents and processes that define UK BIM Level 2 and beyond.

The Roadmap is owned by BSI committee B555 Construction design, modelling and data exchange, which brings together leading institutions and organisations around the BIM agenda. The latest iteration of the Roadmap is produced here for your information and updates can be viewed by following the links in the document.

8.1 Introduction

The purpose of this 'Roadmap' is to document and describe the activities of the BSI B/555 committee (Construction 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. The document also incorporates the activities in support of the 2011 HMG BIM Strategy.

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 (see Table 8.1) should be applied.

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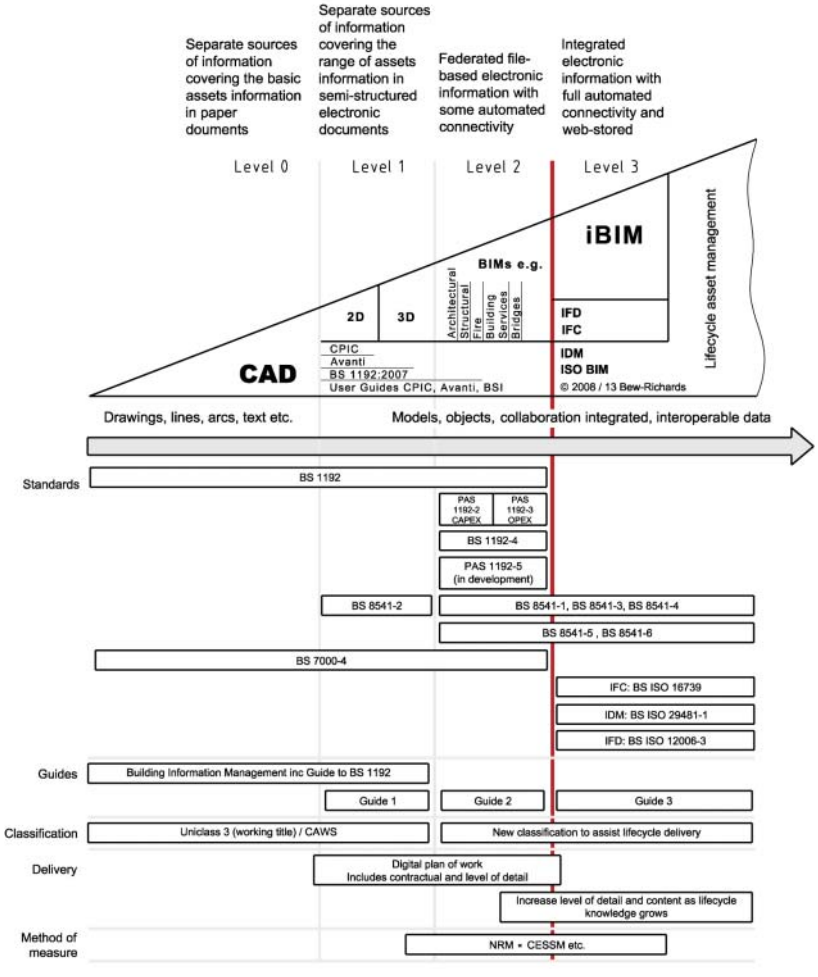
B/555 Roadmap (FEBRUARY 2015 Update)

Design, Construction & Operational Data & Process Management for the Built Environment

Maturity Model:



A) In Preparation

IFD = International Framework for Dictionaries
IFC = Industry Foundation Classes
IDM = Information Delivery Manual

Table 8.1 Standards mentioned in this chapter.

Standard	Date
BS 1192:2007 Collaborative production of architectural, engineering and construction information. Code of practice	2007
BS 7000-4:2013 Design management systems. Guide to managing design in construction	Dec 2013
BS 8541-2: Library Objects for Architecture, Engineering and Construction: Recommended 2D symbols of building elements for use in building information modelling.	2011
BS 8541-1: Library Objects for Architecture, Engineering and Construction: Identification and classification	2012
BS 8541-3: Library Objects for Architecture, Engineering and Construction: Shape and measurement	2012
BS 8541-4: Library Objects for Architecture, Engineering and Construction: Attributes for specification and assessment	2012
BS 8541-5: Library Objects for Architecture, Engineering and Construction: Assemblies	Spring 2015
BS 8541-6: Library Objects for Architecture, Engineering and Construction: Product and Facility Declarations	Spring 2015
PAS 1192-2: Specification for information management for the capital/delivery phase of construction projects using building information modelling	Feb 2013
PAS 1192-3: Specification for information management for the operational phase of assets using building information modelling.	March 2014
BS 1192-4: Collaborative production of information Part 4 – Fulfilling employers information exchange requirements using COBie	September 2014

8.2 Maturity 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 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.
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.

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 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' to aid clarity of application within the operational and delivery market. July 2011 marked the formal release of the UK Government's BIM Strategy. The effect of this has been to set a focused timescale for the adoption of technologies and process to deliver significant cost and carbon performance improvement across the industry. Key to the strategy is the need to deliver Level 2 BIM capabilities with combined model, drawing and COBie data deliveries to the client at defined points throughout the delivery and handover process. To achieve this, clear contractual and delivery guidance is being made available to the supply chain. The PAS 1192-2 and 3 documents form the first parts of this guidance. On successful completion of the Early Adopter programmes, the documents and processes will be refined and converted into full British Standards.

8.3 Key Roadmap deliveries

Currently available in the market today is BS 1192:2007, which 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 jointly published a guide – Building Information Management: A Standard Framework and Guide to BS 1192 – in September 2010.

8.3.1 Delivery 1: 2011–present – object libraries

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 has been rectified with the release of BS 8541:2:2011. These symbols are predominantly for use at Level 1 and as such form a useful reference in the current market as well as a consistency through the maturity levels.

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. The BS 8541 series in its various sections addresses this issue.

- **BS 8541:1:2012** – Introduces library objects, represented in appropriate formats for use at Level 0 (blocks, cells) through to Level 3 (IFC objects). The document refers to draft PAS 1192-2 and object-based principals for identification (naming) and grouping (layering and classifications), it also includes identification of source.

- **BS 8541:3:2012** – Defines 3D symbols in multiple levels of detail. This is essentially focused on Levels 1 to 2, to represent the analysed and designed output as the first level representation in a real world. The standard includes functional and geometric quantity measures (volume, projected area, plan area, effective length, etc).
- **BS 8541:4:2012** – Defines properties and multiple levels of information. This essentially focuses on Levels 2 to 3. The document includes:
  - properties required for specification/selection
  - environmental, cost and social impacts.
- **BS 8541-5:2015** – 'Assemblies' will cover the sharing of submodels representing combinations of components (with their associated types and systems) and spaces (with their associated levels and zones). It will cover naming, classification and nesting.
- **BS 8541-6:2015** – 'Product and Facility declarations' will cover the sharing of data expected from product declarations, labelling and environmental tables. The numeric values need to be supported with details of the relevant lifecycle stage and details of its standard or special 'scenario'. This would offer IFC and IFCXML and COBie presentations and relate these to the standard printed forms. It will include data for waste.

8.3.2 Delivery 2: 2013–14 – process and data management

PAS 1192-2:2013 is an early adopter document to enable the delivery of HMG BIM strategy projects to Level 2 maturity indicator. It was created as a PAS due to time constraints and the low level of maturity in the practising industry. Published in February 2013, the document describes the Capital delivery phase of the project during design and construction. The document incorporates the principles of the Soft Landings delivery scheme to ensure a managed handover into post-occupancy and operations.

In December 2013, the PAS was suggested to ISO as a new work item proposal to fill the gap for international Level 2 guidance. The work on ISO 19650 has commenced.

PAS 1192-3:2014 is the partner document to PAS 1192-2:2013 and also an early adopter document to enable the delivery of HMG BIM strategy projects to Level 2 maturity indicator. It was also created as a PAS due to time constraints and the low level of maturity in the practising industry. This document offers guidance on the use and maintenance of the asset information model (AIM) to support the planned preventative maintenance programme and the portfolio management activity for the life of the asset as well as the data transfer process between delivery and operational phases.

PAS 1192-3 references existing standards including PAS 55 and ISO 55000, the document Asset Management series, as well as Facilities Management British Standards BS 8536, BS 8572, BS 8587, BS 8210 and BS 8544, to ensure no overlaps or ambiguities are introduced.

Both documents build on BS 1192:2007 and enable users to make use of the various new technologies and processes. It is clear that as new technologies and collaboration techniques come to market even more explicit guidance needs to be made available to aid knowledge dissemination.

PAS 1192-2 and PAS 1192-3 are specific to their intended audience as the needs of clients, suppliers and users differ significantly. For this reason, the documentation has been provided in two documents: the first focusing on the 'Capital Delivery' phase and the second on 'Operational Delivery' issues. Both document both data and process management issues. Key issues dealt with include:

- Process definitions.
- Data management for data definitions used for
  - production and operation;
  - libraries an 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 RIBA stages and so on, will start to align with these standards through work being undertaken by the institutions, the BIM Task Group and the CIC.

The two documents 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 is defined.

BS 7000:4:2013 Design Management Systems: Guide to managing design in construction is a revision of a 1996 standard, which documents the overall design coordination process and the planned management of the project data delivery synchronised across all participating disciplines. This document has been updated with references to the new BIM protocol at Level 2 BIM and PAS 1192:2:2013.

BS 1192-4:2014 Collaborative production of information. Fulfilling employer's information exchange requirements using COBie is required on all Government construction projects where information must flow into portfolio, asset planning and facility maintenance tools. BS 1192-4 provides users with recommendations on how to use COBie to structure information required for the operation of an asset or facility during the construction process, supporting the processes outlined in PAS 1192-2 and PAS 1192-3.

Further deliveries from BSI and B/555 will include:

- **PAS 1192-5:2015** Specification for security-minded building information modelling, digital built environments and smart asset management. This will provide requirements for security-minded BIM and digital built environments, including a risk assessment process to determine the sensitivity of any information and identify proportionate security requirements for BIM collaboration, which should be applied during all phases of the site/building lifecycle.

  The intended audience for this PAS includes organisations and individuals responsible for the concept, procurement, design, construction, delivery, operation and maintenance of buildings and infrastructure assets. Although specifically targeted at the use of Level 2 BIM, the requirements will provide a foundation to support the evolution of future digital built environments and will enable smart asset management.
- **BS 8541-7 –** Library objects: 'Specification templates'. Scope to be decided.

- **BS 8541-8** – Library objects: 'Design engineering' MEP design parameters. Scope to be decided.

8.3.3 Delivery 3: 2015–onwards – 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. For 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 following documents described are indicated on the Maturity Model.

Guide 1 Level 1

Building Information Management – A Standard Framework and Guide to BS1192 (2007) was published in 2010. It offers clear and detailed guidance as to the application of the standard in a pragmatic form.

Guide 2 Level 2

This will offer guidance on the design, data management and the workflow processes to deliver the CAPEX and OPEX standard. The requirements and content will be defined in the 'Delivery' documents. These will contain the coordinated deliverable of each stakeholder, architect (RIBA), structural (ACE) civil (ICE) and MEP (BSRIA) engineers against the RIBA Plan of Work Stages, embodied in the Digital Plan of Work (please see www.bimtaskgroup.org). 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 datasets, a Level 3 Guide will be developed.

Level 3 BIM Deliverables

The Government is currently defining Level 3 requirements, and this Roadmap will be updated to demonstrate the desired deliverables to meet these, including a standardisation programme that may include national and international standards.

8.3.4 Other BSI BIM publications

BS ISO 16739:2013 – Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries.

BS ISO 15686-4:2014 – Building Construction – Service Life Planning – Part 4: Service Life Planning using Building Information Modelling.

All British Standards and other BSI documents are available from the BSI shop: http://shop.bsigroup.com/.

The updated B/555 Roadmap is available at: http://shop.bsigroup.com/bim.

Chapter 9

UK BIM Level 2: Key Documents

John Eynon

In 2011, the UK Government Construction Strategy set targets for reducing capital costs in the public sector by 20% and meeting the UK carbon reduction commitments, which include reducing emissions by 50% by 2019.

The report highlighted a number of aspects for achieving these targets and the use of BIM was mandated as one of the key components in the strategy. This set in motion the BIM Task Group, producing several reports, initiatives, working groups and pilot projects.

Meanwhile, the construction industry has continued to grapple with adopting BIM on projects, with varying degrees of success, and also numerous conferences have taken place and groups have been developed, recently including the CIC regional BIM Hubs, founded in 2012.

However, the frequent cry is that we need guidance and standards; and while those leading the initiative have openly acknowledged this, there have been a number of working groups beavering away in the background over the last few years to deliver exactly the information the industry needs. These are now the Level 2 documents.

The following documents represent 'the 8 pillars of BIM Level 2' (Figure 9.1) and, unfortunately, are required reading and understanding. There is no short cut. All of us need to at least have some knowledge of these standards and processes, at a minimum relative to our own role, but beyond that to understand the context within which project teams will be working from now on.

I've also added a few other items that will inform these eight documents and will prove useful.

I can only re-emphasise that there is no shortcut here. Whatever your role and position in the foodchain, you will need to review all the documents and understand the requirements from your perspective.

These documents provide the framework for BIM Level 2 in terms of processes, conventions, contractual arrangements and roles. It is worth remembering that while the standards define various roles, these aren't necessarily, or intended to be, extra people in the team or on the payroll. However, they represent activities that must be carried out for the BIM CDE environment to be effective. So think along the lines of 'What needs to be done?' and then 'Who is best placed to do it?'

Construction Manager's BIM Handbook, First Edition. John Eynon.

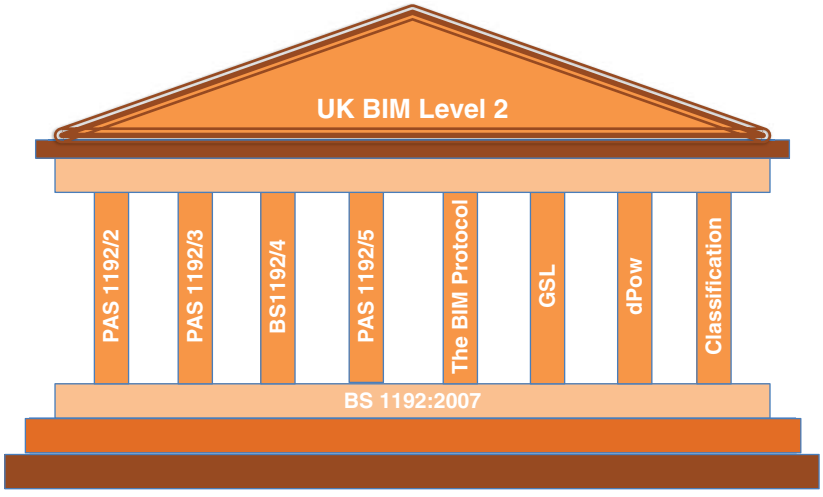


Figure 9.1 The eight pillars of BIM Level 2.

All the documents are freely available on the Government BIM website, and a shortly to be available BSI BIM Level 2 website. The Task Group welcomes feedback on the documents as they are being used by industry.

Just register and log in at: http://www.bimtaskgroup.org/task-group-labs/.

9.1 But first … What is UK BIM Level 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.

The above is taken from Chapter 8 on the B555 Roadmap. As we saw there, BIM levels have been given some definition in the Bew–Richards maturity diagram (known loosely as the Wedge).

At BIM Level 2, in a way this works just as we should now but in a digital environment. Each discipline still produces its own digital information and models. These are shared through a collaboration platform, such as 4Projects or Basestone, and can be aggregated using a software tool such as Navisworks or Solibri. Operations can then be carried out on the aggregated model using BIM tools for timelining, clash detection, quantity take off, simulations and so on. For this reason Level 2 is know as a *composite* or *federated* environment.

It has been said that perhaps BIM Level 2 just makes us carry out the process the way we should have always been doing it. Over the years, generations even, we have learned how to cut corners and buck systems to achieve results. Those results

usually came at the cost of time, quality and cost of the project. BIM is unforgiving – it demands that we follow process properly and the required standards; that we use information consistently and coherently and that we work together properly with the end in mind. I'm sure we could all agree that this is no bad thing, even if getting there is a little painful at times. But it will soon get easier, and the benefits will soon outweigh the apparent cost involved.

Level 3 offers the prospect of working together in a digitally integrated environment. This is way beyond the scope of this *Handbook*, and it is debatable whether current technology can yet support this. Certainly the standards do not exist and the UK BIM Task Group anticipates releasing Level 3 information by 2020 to ensure industry transition by 2025.

However, the main challenge that confronts us now is to ensure industry-wide adoption of Level 2 as quickly as possible. This extends to supply chains, suppliers, subcontractors, consultants, clients, end users, FM/operations and anyone else connected with the brief/design/construct/operate/process.

Perhaps, as technologies and user interfaces evolve, all of this will become more intuitive and just happen in the background. But we're not there yet; and so back to Level 2.

The documents are the following:

- **BS1192:2007** – Collaborative production of architectural, engineering and construction information – Code of Practice

  This document introduces the concept of the Common Data Environment, and collaborative working in a digital format. It can perhaps be considered the 'grandfather' of the eight Level 2 documents as we know them.
- **(1) PAS 1192 Part 2:2013** – Specification for information management for the capital/delivery phase of construction projects using building information modelling

  'The purpose of the PAS is to support the objective to achieve BIM maturity Level 2 by specifying requirements for this level, setting set out the framework for collaborative working on BIM enabled projects and providing specific guidance for the information management requirements associated with projects delivered using BIM.' (Task Group Website)

  The PAS is the key overarching document that builds upon BS 1192:2007, defining the BIM processes for the Common Data Environment on a project for delivery from the start, at definition of need, through to handover, and detailing required management processes in a multidisciplinary BIM environment.
- **(2) PAS1192 Part 3:2014** – Specification for information management for the operational phase of assets using building information modelling

  This takes the process from handover into the full asset lifecycle and details information management for an operational asset to support maintenance and portfolio management activities. It considers the various interventions that might occur over the lifecycle, such as refurbishment, change of owner and recycling.
- **(3) BS 1192 Part 4:2014** – Collaborative production of information – Part 4 Fulfilling employers information requirements using COBie – Code of Practice

Guidance on COBie UK 2012 has been available for some time, but in this update an example project is modelled at various stages with corresponding COBie outputs. In addition, COBie testing and extraction tools are examined.

- **(4) PAS 1192 Part 5:2015** – Specification for security minded building information modelling, digital built environments and smart asset management

  We are increasingly reliant on Cloud-based digital services. This has implications for the world of BIM because we need to consider how safe and secure our digital information really is. The standard discusses the related issues and provides a framework for considering digital security on a project.

- **(5) Government Soft Landings**

  http://www.bimtaskgroup.org/gsl/

  'To champion better outcomes for our built assets during the design & construction stages through Government Soft Landings (GSL) powered by a Building Information Model (BIM) to ensure value is achieved in the operational lifecycle of an asset.' 'BIM + GSL = Better outcomes.'

  (Task Group website)

  Based on the BSRIA Soft Landings process, GSL encourages the engagement of the project end users right from the start of design for any built asset. This improves the built asset design, construction and operation process. Particular focus is on commissioning, handover, end user training, ongoing aftercare and Post Occupancy evaluations.

  The golden thread of GSL runs from the start of a project, linking, clients, end users, designers and constructors, focusing on improved outcomes and operational performance.

  GSL is also a 2016 target. For every Public Sector Project there will be a GSL Champion appointed from the start.

- **(6) Digital Plan of Work**

  http://www.bimtaskgroup.org/digital-plans-of-work/

  A working group has looked at the plethora of industry plans of work and produced the dPoW(see the BIM Toolkit below). This provides a harmonised stage structure that will provide an overarching framework for all other plans of work produced by the Institutes, such as the RIBA Plan of Work 2013 update. Included in the dPoW are activities required for each stage and links with COBie requirements and the Employers Information Requirements.

- **(7) Uniclass 3 (TBC)**

  http://www.bimtaskgroup.org/uniclass-2/

  For a digital information environment like BIM, we need a digital classification system, which was Uniclass 2. This was still effectively a Beta version, but development is now ongoing as below (see the BIM Toolkit), and the classification will continue to evolve with our increasing use of BIM. The classification not only needs to be capable of developing with the growing data maturity of a model, but must also accommodate changes over the asset lifecycle and be capable of use by all stakeholders in the process.

- **(8) CIC BIM Protocol**

  http://www.bimtaskgroup.org/bim-protocol/

  The CIC BIM Protocol is a supplementary contract agreement for appointments by construction clients and contractor clients. It covers BIM model production and

delivery requirements and also sets out information requirements. The protocol can be included in a contract or appointment by a simple amendment as an appendix or supplement.

- **BIM Toolkit (6 and 7 above)**
  http://www.thenbs.com/bimtoolkit/
  RIBA Enterprises/NBS have been appointed through a competition by Innovate UK (previously the Technology Strategy Board) to develop a digital toolkit to cover the development of the Digital Plan of Work and a Digital Classification System. The web tools will be free to industry to use. Stephen Hamil explains this in more detail in Chapter 10.

Other documents include the following:

- **Data Hierarchy**
  http://www.bimtaskgroup.org/data-hierarchy-overview/
  Linking with the dPoW, the Data Hierarchy defines the information requirements for each stage, from general to detailed, including the Coordinated Work Stages, the Plain Language Questions that set out what information is required and also the Demand Matrix, which sets out the information to be included in the COBie file that forms part of each of the information exchanges in line with the dPow.
- **Employers Information Requirements**
  http://www.bimtaskgroup.org/bim-eirs/
  The EIRs are included in tender and appointment documents, defining model requirements and outputs at each stage. The EIRs cover technical, management and commercial aspects of the requirements and are detailed on the website. The Plain Language Questions are used to help the produce the EIR and are available on the Task Group website.
- **Scope of Services for Information Management**
  http://www.bimtaskgroup.org/scope-of-services-for-information-management/
  These documents detail the information management role that is fundamental to BIM delivery on a project, managing the Common Data Environment, project information and facilitating collaborative working, information exchange and project team management. The role does not involve design responsibility. However, it could be carried out by a consultant with design responsibility or the main contractor.
- **Insurance Guidance Note**
  http://www.bimtaskgroup.org/professional-service-indemnity-insurance-guidance/
  The CIC has carried out extensive consultation with the professional indemnity insurance market, and developed some simple guidance for all those involved in design in a BIM environment. Guidance documents are provided on the website.
- **Video resources (under resources tab)**
  http://www.bimtaskgroup.org/video-resources/
  Various leading members of the Task Group have produced videos that give an overview of the Government BIM programme, covering aspects such as Education and Training, Commercial, Technical and Government Soft Landings.

9.2 Conclusion

This is a defining moment in the Government BIM initiative.

At a time when the UK has recently moved into second place in the world in terms of BIM adoption, outranked only by Finland, this comprehensive set of documents provides much-needed guidance and standards for all stakeholders involved in implementing and using BIM on their projects. As these documents become embedded in industry practice, they will provide a platform to move forward in BIM adoption and could well prove to be a landmark in the transformation of our industry.

The recent launch of the Level 3 strategy brings home the fact that Level 2 is but a staging post on the journey. The current challenge is ensuring that our industry operates consistently at Level 2, delivering benefits from improved information delivery, organisation and project performance.

Chapter 10

NBS BIM Toolkit: An Overview

Stephen Hamil

NBS are delivering a Digital Toolkit for Building Information Modelling (BIM) ahead of the 2016 deadline for the use of Level 2 BIM on public sector projects. This work was initiated by the UK Government's BIM Task Group to complete the remaining aspects of Level 2 BIM.

The contract to develop a digital toolkit for BIM, on behalf of Innovate UK, was awarded to NBS in September 2014 ahead of the 2016 deadline for use of collaborative 3D BIM (including electronic project and asset information and documentation) on public sector projects.

The Toolkit is a web-based resource tailor-made to guide users through the construction process. At the heart of the project is a standardised and digitally-enabled classification system coupled with a level-of-definition reference library and digital plan of work tool. Combined, these have the power to transform the delivery of construction projects for all disciplines and across all scales of projects; from large infrastructure schemes to small, domestic-scale works.

Over the first few months of the project, the team consulted with architects, clients, contractors, engineers, manufacturers and facility managers to help ensure that the content and software being developed met the industry need. On the whole, those consulted felt that while current processes allow projects to get built, there are a great many holes in existing process and procedure – and it's exactly these gaps that the Toolkit is designed to fill.

All these discussions made the team certain that the Toolkit has the very real potential to transform the procurement of buildings and infrastructure by defining and testing the BIM data required at each stage of the project. The team are also highly optimistic that the tool will be used in the private sector as well as public because, quite simply, it represents a much smarter way of working.

10.1 What exactly is the BIM Toolkit?

At the heart of the Toolkit will be a new *pan-industry classification system*. This will build on the work NBS has done in recent years under commission from the Construction Information Committee (CPIC).

Construction Manager's BIM Handbook, First Edition. John Eynon.

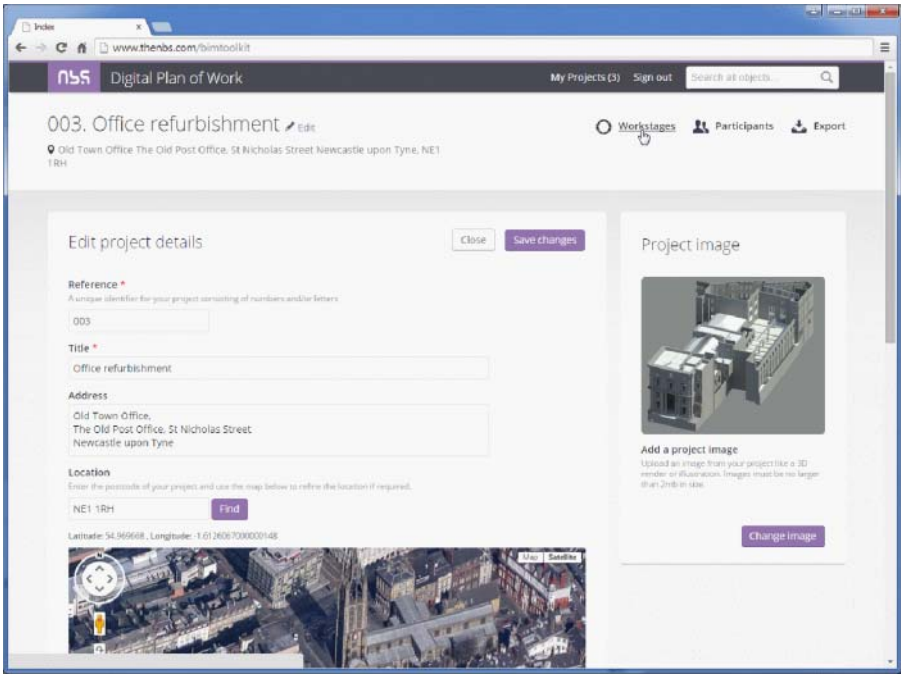


Figure 10.1 A project set-up within the BIM Toolkit.

Based on an extended version of Uniclass, the system will deliver a unified structure for mapping and guidance and will allow objects within a project to be given multiple classifications where appropriate.

The Toolkit will also include more than *5000 templates* setting out both Levels of Detail (LOD) and Levels of Information (LOI) for construction objects.

These templates will include spaces, systems and products for use in building and infrastructure projects. These will be available, for free, from the Toolkit website and will also be downloadable in IFC and Microsoft Excel format.

The Toolkit will also feature a *digital plan of work*, which will enable the project leader to clearly define the team, responsibilities and an information delivery plan for each stage of a project – who, what and when – in terms of documents, geometry and property sets.

Cumulatively, these resources will form the 'construction language' that all project teams can use to define their information exchanges for a particular stage of a project.

The screenshots within this chapter (Figures 10.1–10.3) show how projects, tasks and deliverables may be defined within a Level 2 BIM project.

10.2 What benefits will the digital BIM Toolkit deliver?

Great care is being taken to make the Toolkit easy to use, recognising that organisations will be at varying stages of BIM adoption. Ensuring everyone can access

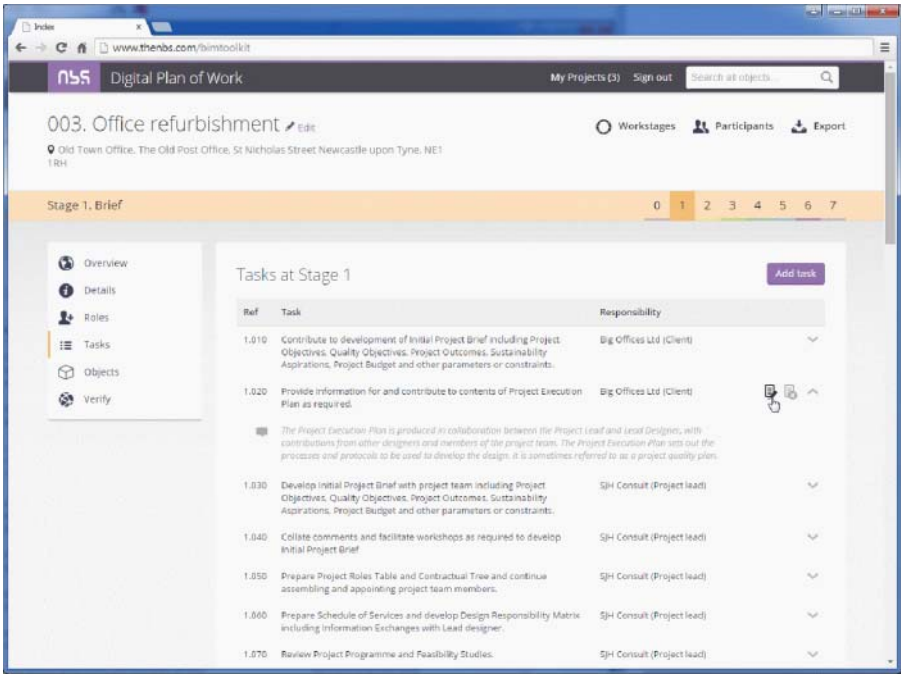


Figure 10.2 Tasks may be assigned to roles for each stage of the project.

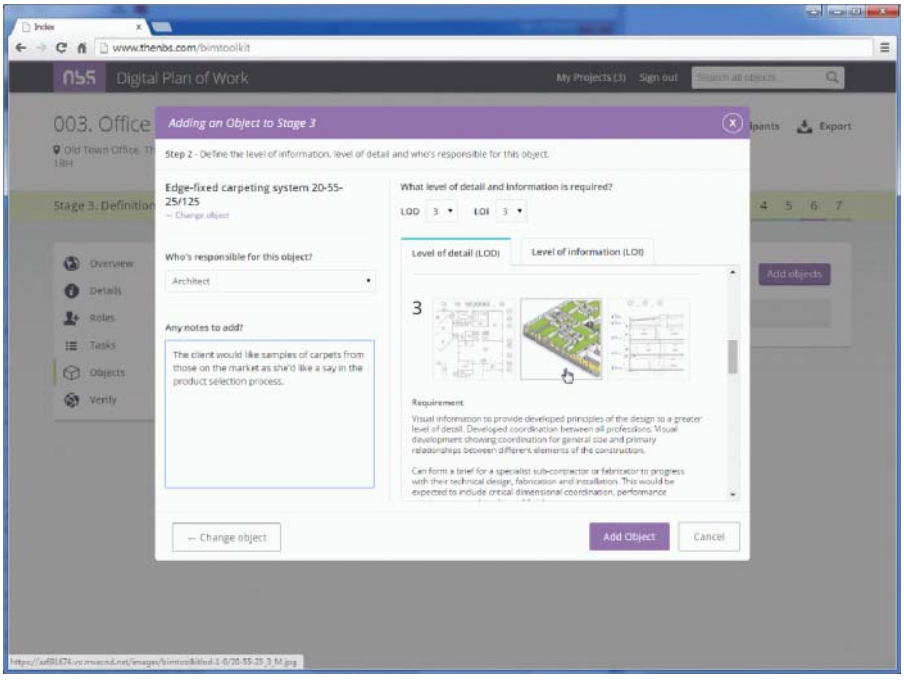


Figure 10.3 For each stage of the project, deliverables may also be clearly defined.

the resource, in line with their individual requirements, will be crucial to spurring the widespread adoption of BIM.

It is hoped that the Toolkit will not only bring synergy to construction projects through the use of BIM, but also realise the benefits of allowing the entire project team to work collaboratively and to the same parameters for the first time. This will represent a step change for the construction industry and will prove critical to the successful implementation of BIM-enabled projects in the future.

10.3 What happens next?

Leading up to April 2015, the project team held a range of events, webinars and seminars as a way of engaging with people across a wide range of disciplines and feeding into the development process at that time. The website is now in full use, and is freely available to the industry to use the toolkit to define the deliverables on their Level 2 BIM projects. For further information, visit: theNBS.com/BIMToolkit.

Chapter 11

BIM-ing the Team

BIM and the Construction Manager, Project Manager, Quantity Surveyor, Estimator, Planner, Technician, Land Surveyor, Engineer, Architect, Site Manager, BIM Manager, Information Manager, Commissioning Manager, Facilities Manager, Owner, Operator, Maintainer …

John Eynon

Having considered what BIM is about and some of the processes and standards for Level 2, the natural next question is 'What does this mean for me, my role, my business or organization?'

In a later chapter we look at some tools to help you start to put a plan together, but to broadly answer the question we need to stand back for a moment and take in the view.

11.1 Smart world

Most of us now have embraced smart technologies almost without noticing. We check our emails, surf the internet, book tickets, check train times, order a taxi or some food, and use apps to do all sorts of things from play a game to check the weather to plan a journey. All of this while we're on the move, not rooted to a desk or a particular spot.

Already this is having a huge impact on our society and communities, but perhaps as the changes are gradual we don't notice them so much.

All that is happening is that this kind of technology is now being applied in design construction and operations with dramatic effects.

I remember when closed-loop ground-bored piles were introduced for sustainable heating and cooling. At the time, site teams scratched their heads and wondered what it was all about. But now it doesn't even raise an eyebrow and systems are installed without a comment, even as part of the everyday. The same could be said about many technological innovations that have been adopted over the last few years and are now 'normal'.

Construction Manager's BIM Handbook, First Edition. John Eynon.

BIM adoption is no different. When the fuss has died down and Level 2 is just the way we work, we won't even mention BIM anymore it will just be what we do every day and be part of the project processes we follow, just like quality, health and safety, and the environment.

So what will it be like? What differences will this make?

11.2 The Swamp

Before we begin to answer these questions, we need to understand where we are.

Clearly the world isn't perfect yet, and while there are good examples of current best practice on BIM as it is understood now, whether that's how it will finally be is another discussion. The changes even over just the last few years demonstrate that a lot can happen on a short timescale. Additionally there are lots of differing opinions out there at the moment on all sorts of BIM-related subjects, and it is going to take some time for this to settle down and become aligned. And, of course, in terms of general impact and understanding, we know that the vast majority of our industry still knows little about BIM nor understands what it means.

I call this *the Swamp*.

Simply because we're in a mix of stuff about BIM – some good, some not so good and some misguided or confused. And, of course, we have the early adopters, champions and beacons, the willing, the hopeful, the undecided and the blockers and naysayers. It will be a while yet before the industry emerges from the Swamp into a more stable digital future. However, we're getting there!

So we need to look beyond our current position to a time where process, impact, acceptance, understanding and technology have developed beyond where we are now. To some extent this involves some future gazing, but if the lessons of the last few decades are to be believed then the reality will be beyond what we imagine. I acknowledge we're not 'there' yet, but when you look around at all that's happening and developing, we can begin to see some vision of how life might be. Admittedly we have several years of exploration, development and up-skilling to get us there.

However, most importantly, let's always remember this migration to digital is absolutely inevitable and unstoppable – it is only a matter of time, as we discuss in the Afterword. This will in time affect businesses, organisations, individual careers, training, education, institutions and probably the shape and structure or the AECO industry.

11.3 Principles of the way it will be …

Let's consider a few ground rules or principles for the future of BIM and the project team roles.

- **Mobile** – increasingly our technology and accessibility is built around mobility. Use of smart phones and tablets are current examples. Generally we are becoming less reliant on desk-based systems. Work is continuing on reducing the size of processing chips and increasing the power of the equipment available.

- **Connection** – the networks we use, now 4G, and the widespread use of Wi-Fi hotspots provides increased connectivity and bandwidth and is improving to provide the volumes of transmission that we need. As technology progresses, this will continue to improve.
- **Open** – collaboration and convergence between software platforms will improve, as will the use of COBie and eventually IFC will become standard. Exchange of information will not be reliant on the software platform.
- **Information** – all your project's information will be available digitally through a CDE, and as a consequence of the above aspects, anytime, anywhere. Whether your information is all in 'one' BIM or location online remains to be seen. It really doesn't matter – we access all kinds of information every day from all sorts of sources. The browsers, tools and search engines that we use sort that all out for us, collating and aggregating and linking us to the sources and data we need.
- **Libraries** – of data and information will be more common, some will be free, some by subscription. It will depend on how the commercial model for the particular library works so, say, manufacturers pay for the information to be hosted so that it's free to specifiers. Libraries will include all kinds of industry-wide data, for products, costs, building types, designs, manufacturing, maintenance, operational and so on.
- **Technology** – will continue to improve to become lighter, faster, more powerful, it will be something like science fiction, with headsets, immersive experiences, touch surfaces, holograms, 3D projectors, printing, making. Anything that enables us to access, create and make using digitally based technologies. We have barely scratched the surface, and are in the foothills of the mountains of the application of this technology to the built environment industry.
- **Accessibility** – in the fullness of time, software will become more intuitive to use and easier to interface with. When you stand back, it's amazing how quickly we've become used to tapping, swiping, pinching, sliding the screen on touch surfaces and picking up apps and playing with them – even children do it! BIM will just be the same – all the hard stuff will happen in the background while we're tapping away on a user interface that makes it all look so simple.
- **Augmented** – we are already seeing augmented reality tools in use – tablets, goggles, headsets, caves, where the digital reality can be experienced but overlaid on the reality also. These are sometimes called immersive experiences because our senses are immersed in the digital world. To be able to see the digital reality in juxtaposition with the physical is a powerful tool not only for providing the change but also for seeing what needs to be done.
- **Manufacturing** – the use of BIM ideally lends itself to offsite manufacture and prefabrication. Information can be sent to computer-driven manufacturing plants. Or perhaps local or site based industrial sized 3D printers – another rapidly developing technology. Why ship it from China when you can print it right here?
- **Consistent information** – the Holy Grail – all data, right across the industry, will be structured, referenced, organised, labelled in just the same way. All the barriers, silos and boundary lines that prevent our sharing of information consistently and efficiently will be gone. The tools we use will both make sense of data in different locations and databases and give it to us the way we want it. Harmonised

classification will be running in the background, so that whether we're cost planning, specifying, building or maintaining, the information will all be correlated and referenced for our ease of use. Our industry has been notoriously poor at dealing with information in a structured and consistent fashion. In fact we are very good at the exact opposite!

- **Democratisation** – the technology, processes and developments that we're discussing create an environment where all the players can be equal. The SME can compete on the same platform as the multinational. Each stakeholder in the project can participate, access and manipulate the information for their use. So who manages the process? Anyone with the capability. It has been said we are all architects now. Equally we are all engineers, surveyors, contractors, managers and operators, creators and makers – if we want to be! With the right skills and access to the right information, *anyone* could do this. Consistent structured data available in the Cloud, libraries of benchmarked information, products and designs, and intuitive software – with previously unimagined processing power and connectivity – open up this world to anyone who has the desire and can amass the capability. The ultimate information economy and democracy.
- **Technologists** – as much as we can all be architects, so we will all have to be technologists to a lesser or greater extent. As we discussed earlier, we've taken on board the smart technology and tools. And so it is with BIM implementation. There is no short cut. You have to read the stuff, learn some of the terminology and get familiar with the tools and how it works for you. Then, depending on your role, you will need to understand the appropriate tools, processes and protocols.

11.4 BIM-ing the team

So, as we move to consider some of the main team roles, if we have taken on board all of the above factors then we can see that life is going to be potentially very different for everyone in team, irrespective of their place in the project chain. The flow of information, technology and process extends to all levels of involvement and across all of our current silos and boundaries.

It is the information and data that makes the difference. The 24/7 accessibility, anywhere. At home, on the train, in the meeting, the diner, the coffee bar and so on. Flip out your supercharged tablet on 6G – as it will be – and the world's your oyster.

And remember much of this information will be available real time and up to date – *current*.

So … let's consider a few roles and how this might impact the team.

11.4.1 The construction manager

Most of the CMs that I've worked with are very busy people. A lot of their time is tied up with checking the state of play on issues and managing their team. Whether it's work on site, design, manufacturing offsite, safety, compliance or a whole plethora of other things. Reporting and paperwork take up a lot of their time, both in amassing

information and then presenting it to the interested parties – whether that be the client and their team, senior management or third parties.

- **Progress** – the project programme will be in 4D BIM, using a tool like Synchro, with outputs to Primavera or Asta. Site managers with Field BIM-enabled tablets – or perhaps even tiny drones – will update on progress as they move round the site. This can sync with the project BIM and a progress model can be available in real time to view or output as required. Naturally, the actual progress can be highlighted against the planned.
- **Planning and logistics** – simulations of the construction process can be run to view, review and adjust the construction sequence and methodology. This can include assessing health and safety, access and logistics issues.
- **Onsite** – using BIM stations or their own field connections, subcontractors and suppliers can access the project BIM and discuss their activity for the day. They can look at what needs to happen each day, the activity points, where the materials are and any logistics and safety issues involved.
- **Offsite** – elements from the project BIM are output to computer-driven manufacturing facilities. Components are RFID tagged so they can be tracked and checked against the manufacturing and delivery schedule. Status reports will be in real time.
- **Design** – the project BIM is available in real time to be assessed, reviewed, validated and checked any time. This can include compliance with regulations and statutory requirements. Outputs and deliverables are geared to the digital Plan of Work and can be checked for project completeness. Environmental and lifecycle simulations can be available to provide the overview on the FM/operational outputs for the project. This can be checked against the Post Occupancy Evaluation measurements as part of the Soft Landings process.
- **CDE** – all the project information is held in a collaboration platform. Transparent, accessible and available.
- **Dashboard** – the use of dashboards is growing, and it's quite possible that the construction manager will have a super dashboard for the project. Linked to the project BIM and databases, showing the status on the project – design, manufacture, delivery, safety, construction, resourcing, environmental. As many factors or aspects as you wish. Probably on a Red Amber Green basis. At a glance, the CM can see the status of their project.
- **Reporting, updating** – virtual meetings and presentations will become more commonplace. The cost of getting people together is enormous. Why bother when the information you want to see is available to view and interact with, anytime, at your leisure? Presentations, reports, dashboards can be talked and walked through online.

11.4.2 Pre-construction manager and delivery construction manager

Pre-construction and delivery are very different phases of the project, arguably involving different skills, capabilities, mindsets and perhaps personalities. The distinction

between pre-construction management and delivery construction management deserves more industry recognition.

However, the tools and use of the CDE take the strain out of the historic analogue-style activities that we are used to. This enables us to spend more time on actually thinking about what we are doing and becoming more efficient in the process.

As can be seen, the pre-construction manager will have multiple streams of data available to manage the design, estimating, planning and procurement processes.

11.4.3 Design manager

For the DM, we can say all of the above but significant areas include clash detection routines. The use of a volume strategy, as PAS 1192/2, should minimise and control interface issues, clash detection routines would then detect and enable the resolution of anything that falls through the net. This in itself will be a huge time saver. Gone will be the days of the pile of drawings and a red pen. Hooray!

Second, with linking of activities and deliverables to the dPOW, plus the validation tools that are and will be available then, also gone are the days when someone says 'we've given you a stage 3 design' and it then takes three months to find out that they haven't. The computer will say no at this point, and you will be able to reply, 'We've validated your model. It is not stage 3, you have clashes in these areas, non-compliances in these areas, and it is incomplete here, here and here. Please finish it off and resubmit!' Design managers up and down the UK will be sleeping soundly in their beds, knowing that they can at last properly control and manage the design process, and immediately understand what is and isn't happening.

11.4.4 Estimator, quantity surveyor, commercial manager

Again, all of the above for these roles plus the addition of the significant 5D element.

Quantities and schedules can be extracted from the model environment. However, the model must be constructed properly to enable this to happen – including the correct data, attributes and classifications. Automated quantity take off from the model provides quantities and schedules; costs can then be applied for the basis of a cost plan.

The take off as an analogue process is laborious and long-winded. Automated take offs, schedules and specifications will become the norm, saving time and improving reliability. They will be used both pre- and post-tender. Exchange of digital information with suppliers, manufacturers and subcontractors will speed up and improve the quality and accuracy of procurement. Using a CDE lends itself to optioneering at various stages, so assessing the commercial implications of different components, systems and construction processes can be assessed quickly.

Add to this the possibility of benchmarked industry cost, procurement and programme data, then, when all these are linked up, this becomes a very potent project tool.

When considering team roles, it is the availability of consistent, structured digital information coupled with tools for authoring and analysis that opens up the possibilities of groundbreaking change.

In understanding our roles it is necessary to follow the information flows, consider the activities required, outputs and the tools and technologies needed to facilitate them effectively.

11.4.5 BIM manager, coordinator

Over the last few years a number of job titles with 'BIM' have developed. Not surprisingly, most of these titles are going to have a short lifespan. As BIM processes and understanding become embedded in the mainstream then the need for these roles will reduce and become absorbed into other roles – as it should be.

It is worth noting that the 1192 series identifies various roles such as the information manager and others. These aren't intended as additional seats round the table. These are roles and activities that can be carried out by existing team members as part of an expanded job description or scope of services. As for the BIM consultants and the various companies that have entered the market, there will always be a need for specialist input and outsourcing to even out resourcing peaks and troughs, but again in time this market will mature, settle down and broaden into project-related support services.

Most companies will have a document or information controller-type role. Usually low paid, undervalued but ironically critically important to success. As we can see, if the information isn't right, then we don't have a hope of getting anything else right!

So, I would expect these kinds of roles to expand and develop to take in information management, collaboration platforms, CDEs and probably some ICT skills. This is a pivotal role and is worthy of recognition and status.

As we have seen, now it's all about the information!

11.5 The final stretch

As we conclude this chapter, I'll leave you with three vignettes of a future AECO industry:

1. You are a client. You need a building of some kind. You go to a showroom on Oxford Street in London. At first glance you might think it's a car showroom, but there are no cars to be seen – just a few desks, some massive screens and a few projectors.

You sit down with Karen, your visualiser for the day, and you go to work. You discuss your ambitions for your project, together with your needs, ideas, timescales and budgets. Working through libraries of projects, design, data and exemplars, Karen builds a project model for you. The site data is imported from the urban GIS BIM. You build your project virtually. Using benchmarked industry data, you compile your project in line with your budget, desired timescale and level of specification and operational performance.

You put on the headset and have an immersive walkthrough together of the finished project. You can see the colours, the quality, smell the coffee even. Having thoroughly reviewed it, you sign the model off.

Karen immediately submits the model online to the Urban BIM authority. You get planning and building regulations clearance within 20 minutes.

Together you check availability of a tech team and manufacturing lines.

Factory slots are booked. A site prep team is booked in for a few weeks time, with the superstructure and elements beginning delivery and assembly over the next six weeks. Programme, price and quality are set. You leave the showroom, knowing that your project will be delivered to your requirements … and now for that pair of shoes.

2. Arvinda Khan is a CIOB Construction Manager responsible for the £10bn refurbishment of the Houses of Parliament/Westminster Palace.

She has a busy diary. Today she has updated the Parliamentary Committee responsible for the project, reviewed design progress and significant coordination issues with the design team, vetted the procurement strategy with her commercial team, and checked the offsite manufacture, progress and quality of the new office and core pods with the specialist supplier in China.

Today is also one of the days in the week when she works from home, to look after her children while her partner is in New York on a business trip. With access to the dashboards and data that Arvinda needs, she maximises her time using virtual meeting tools and drives her team and the project forward.

Her team of design, procurement and construction specialists are based around the world. Collaborating efficiently in a totally digital and accessible networked environment.

3. Imagine a world where the number of people on site reduces by 75%. No surveyors, no design managers, coordinators, BIM managers, information controllers or adminstrators. The only people on site are the ones who actually *build* the project – technologists/engineers.

Imagine a world where all the design and package procurement has been completed before we start on site. Where all the options have been explored before we make, where all the costs have been agreed before we create. Where no changes occur when we're on assembly and construction.

Everyone in the team is working to their strengths at each stage. Designers design. Builders build. Cost and project managers manage.

We know we need to work differently, better. A change would do us good!

11.6 And finally for this chapter …

You might want to argue with this. That's fine; go ahead. However, this is an argument that no one needs to win – this is inevitable, it is only a matter of time. Over my lifetime technology has changed beyond imagination and recognition, but our industry in reality has changed very little.

This is all about to change!

And this is radical, bottom up, top down, inevitable, irresistible and … about time. The flow of what is happening now is irresistible.

The ideas we've discussed above are all happening now in some shape or form somewhere around the world. We imagine the future on the basis of what we know. If

the lessons of just the last few years are anything to go by, then we can see the future will be absolutely amazing and beyond our imaginings. The future is already here.

This vision for our industry goes way beyond BIM. This is about being a world-class industry, taking our place in leading the global information economy.

It is time for our industry to grow up and become mature, collaborative, respected, aspired to, truly diverse and fully inclusive. Totally responsible in both process and product, leaving a sustainable legacy for future generations in the fullest sense of those words. We need now to embrace all of this as soon as we can. We are all part of the problem of what's wrong with our industry and, ironically, we are all part of the solution.

As Gen Y and Gen Z come through into positions of leadership, they are going to show us how this really works and lead a change programme that will be the most formative and transformational since the First Industrial Revolution. We haven't seen anything yet!

Chapter 12

BIM Level 2: Legal Perspective

Sarah Rock

In reality, the adoption by the UK construction industry of Level 2 BIM brings about very few legal issues. As each party retains responsibility and ownership of its design, the legal documents that have been used to record and regulate the pre-BIM construction world remain – albeit with a few small but crucial amendments.

Standard form building contracts will continue to hold court. The producers of these have recognised the minor changes required to incorporate BIM legally; the JCT supplement and NEC 'how to' guide offer some guidance for the free drafting of clauses required to make these suites 'BIM friendly'. The CIOB Complex Projects Contract remains, at the time of writing, the only standard form building contract to contain BIM provisions ready for use. [1] All other contracts require drafting amendments to facilitate the necessary small changes, for example legal incorporation of a BIM Protocol.

12.1 EIR and BEP: design and build for BIM

When a client first sets out on a BIM journey, the end goal should be the starting point. While the BIM process assists and allows for a more efficient design process, BIM shows real benefit at the point of handover of the building into the facilities management (FM) stage. The drawings and operating and maintenance information in the model negate the requirement for a multitude of folders of information to be stored for FM – it is now readily available at the click of a mouse button or touch of the screen. However, in order to ensure that the information contained within the model is as required for the FM team, the client needs to evaluate this need right at the start and throughout the design and build, perhaps by implementing Government Soft Landings (GSL). Inclusion of the FM team from day one provides a helpful reminder of the long-term gain and purpose of using BIM.

In order to produce a model that meets the needs of this ultimate end user, the client should put together an Employer's Information Requirement (EIR) document. A BIM consultant or member of the design team can assist clients who are new to the process. The EIR document then acts in a similar manner to Employer's Requirements

[1] The revised ICC conditions contain simple provisions requiring compliance of an agreed BIM protocol for civil engineering projects.

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in a design and build project. The EIR does not become incorporated as a contractual document, but should be referenced in the building contract.

In response to the EIR, the design team produce a BIM Execution Plan (BEP) that acts like design and build Contractor's Proposals. The BEP responds to the client's requirements from the EIR and provides roles and obligations to meet them. This document is also referred to in the contract, but due to its evolving nature is not included as a fixed document.

12.2 The BIM Protocol

A BIM Protocol is intended to provide commonality across the design team for a project with regard to the structure, coordination and use of project information. The Protocol dictates various elements that are crucial to the smooth running of a BIM-enabled project, such as software choice, timing of freezing points and data drops, filing naming conventions and provision of the Common Data Environment (CDE). Also included is a model production and a delivery table that dictate the models to be produced for the project, identification of the party to produce them and to what level of detail they are required. The Protocol is produced further to the EIR and BEP and allows for contractual incorporation of the relevant terms, allowing for legal implementation of the processes and procedures required to produce a model that adheres to these two higher level documents.

The importance of adhering to a legally binding Protocol is highlighted, for example, by the potential risk that one consultant does not comply with the pre-agreed freezing points. This could lead to all other members of the design team working to an out of date model from one particular discipline, which could obviously result in delays and cost. Bespoke BIM Protocols have been used on individual projects and their legal standing varies (depending on the contractual provisions that govern them). A Protocol should be appended to all relevant contract documents on a BIM project, with drafting amendments made in the contracts to incorporate the Protocol – if it is just appended without a clause requiring adherence to the Protocol, it becomes simply a floating document with no contractual obligation to work in line with its provisions.

The CIC Protocol launched in 2013 provides a standard form Protocol that is intended to be incorporated into the building contract, as well as relevant appointments and subcontracts. Clause 2 of the CIC Protocol states that in the event of any conflict or inconsistency between the Protocol and any other documents, the terms of the Protocol prevail. The CIC Protocol therefore provides a level of comfort and clear identification of legal responsibility for all involved. However, while the CIC Protocol offers a valid attempt to address the legal obligations raised by use of BIM, all practical requirements, such as the model production and delivery table, choice of software and so on, are reduced to the two appendices and these need to be carefully considered and completed. It is very easy for a client to incorporate the Protocol without fully understanding that unless these sections are filled out with the correct information specific to the project they may as well be inserting a blank piece of paper!

12.3 The information manager

The CIC Protocol introduced the role of information manager and the CIC published a standard form of appointment for the role. Principal responsibilities of the information manager (also referred to as the BIM manager) include managing information exchange and practical implementation of the Protocol. The role may be adopted by the lead designer, but increasingly this is becoming a standalone role allowing for objective management of the processes and obligations across the rest of the design team. An individual appointment is required where the information manager is providing that role on its own. If the information manager is part of the existing design team, the obligations from the appointment can be drafted into the overall appointment.

12.4 BIM competency

When drafting the information manager's appointment, regard should be had to the provisions, ensuring the role is to be carried out with the suitable level of skill and care. While there are publically available standards in place, BS1192:2007 and so on (see Section 12.5), there is little in the way of clear-cut standards for the design team members to adhere to when working with BIM. As use of BIM becomes more commonplace, and standards are ironed out or provided for during initial training, this will become clearer. However, at the time of writing, what the consultants are expected to do in exercising the reasonable standard of skill, care and diligence in performing the role of a properly qualified and competent 'BIM' consultant is still uncertain. Consultants should therefore exercise caution in promising too much to clients. Qualifications such as BIM accreditation or degrees in architecture (incorporating BIM) may assist in ascertaining what the market standard is, but the evolving nature of this new technology leaves a level of uncertainty here, potentially exposing certain consultants.

12.5 Standards

While there is no recognised standard for a 'BIM' architect as yet, there are a set of standards evolving that dictate and govern the processes and set out best practice. The suite includes:

- BS 1192:2007 – Collaborative production of architectural, engineering and construction information.
- PAS 1192-2 – Specification for information management for the capital/delivery phase of construction projects using building information modelling.
- PAS1192-3 – Specification for information management for the operational phase of assets using building information modelling (BIM).
- BS1192-4 – Collaborative production of information Part 4: Fulfilling employer's information exchange requirements using COBie – Code of practice.
- PAS 1192-5 – Specification for security-minded building information management, digital built environments and smart asset management (currently in development).

These documents need to be fully understood by members of the BIM team and the procedures included enacted on projects. The standards provide the bulk of the pillars of Level 2 wisdom. The standards can be referred to in the contractual documents; however, they are commonplace in the BIM community now and so any consultant who did not adhere to them or implement them would clearly be acting without exercising the correct level of diligence for this area.

12.6 Intellectual property

At Level 2 BIM each designer retains control and ownership of their own models. The IP process therefore alters very little from the pre-BIM world and thus there is little need for whole-scale IP drafting amendments. Correct author labelling and file naming should allow for identification of the model elements with the model author. The client should receive a license to use the models and the information contained within them. If manufacturer's objects are used within the model the consultant inserting them should obtain a license for them to be used and for the client to use them going forward.

12.7 Security of data

Potential corruption of the data in the model should be addressed through the implementation of security processes. PAS1192-5 sets out a framework for the client to follow, including a triage process to ascertain what level of security is required for any given project. Clause 5 of the CIC BIM Protocol should be viewed in light of PAS1192-5. Elements such as the integrity of electronic data and the risk of corruption of data are in danger of becoming floating obligations with no party taking on the responsibility of ensuring the correct procedures are in place to safeguard the client and the data. On a project with a sensitive build involved, it seems prudent to allocate these risks and obligations specifically in order to ensure that all measures are taken for a secure CDE and protected sharing of information at the correct levels. Clear drafting within the contract documents and appointments allocating responsibility for validity of data, provision of platforms and data storage, security of information and so on is crucial to ensure that the client and/or potentially sensitive date are not left exposed.

12.8 Key documents

From a legal perspective, one would expect to see the following documents included or referenced into the contractual documentation associated with a construction project:

- EIR.
- BEP.
- BIM Protocol.
- Associated drafting of clauses to incorporate or to reference the EIR, BEP and Protocol.

- Drafting of clauses to reflect incorporation or reference to the 1192 suite of standards.
- Information manager's appointment or drafting of clauses to reflect the role within the appointment of another consultant on the project.

12.9 Legal conclusions

While Level 2 BIM provides a huge leap forward for technology use and application in the UK construction industry, it does not bring with it the need for widespread legal changes and alterations. Existing forms of contracts are still suitable, albeit with slight drafting amendments to reflect the nuances that BIM brings. A few new documents are required to fully record the liabilities and obligations of the team and in particular the BIM manager. So, while it is not exactly business as usual, the amendments required to reflect the process and the roles are minimal and should in no way hold up use of BIM on a project. Keep calm and carry on …

Part IV
WIDER CONTEXT

Chapter 13

5D BIM: Cost

BIM Case Study: Henry Riley – The 5D QS

Adrien Guillemet

With the emergence of BIM processes in the form of standards and technologies, the role of the quantity surveyor (QS) is evolving. What used to be a traditional 2D costing activity is now turning into 3D measuring along with information data management. In a standard BIM project, the information created by the different designers and consultant does not, contrary to common belief, only consist of a digitised 3D model, but also comprises information regarding that model and the whole project in general. Knowing how to manage and utilise that new extended dataset is what turns the traditional QS into a new-era 5D QS.

Let's start our discussion of what the role of 5D QS entails by first highlighting some key BIM good practice bullet points and where the QS sits with regards to them. For a BIM project to be successful, several elements need to be in place:

- The various design team members and construction consultants need to be clearly defined and all must understand where the different roles and responsibilities lie within the group. To help with this, a responsibility matrix can be inserted in the BEP (BIM Execution Plan) to present that information. It is very important for the QS to know which dataset was created or needs to be created by which designer as it will inform the review of the data and cost estimation of the model.
- Once the project is under way, data will start being produced by the different team members. It needs to be agreed by everyone before the beginning of the project where that data is going to sit or be hosted, how the access to that data will be managed, and in what format the data will be. In other words, a CDE (Common Data Environment) needs to be set up. A Cloud system is now becoming the more preferred way of achieving the hosting of the data, where the team members can upload and download the data relevant to their role. Examples are, but are not restricted to, Autodesk 360 and Graphisoft BIMX. As for the data itself, it is clear that almost no data produced by any of the project stakeholders will be standing on its own, as it is very likely that any stakeholder's data production will be affected somebody else's. The data is therefore meant to be readable by all. This means

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that IT solutions in the form of a set of software packages and data file formats need to be agreed and documented as part of the BEP. For us at Henry Riley, it means that we make clear which file format will work for us on our costing software platform. We tend to use CostX as our main costing tool, which requires files to be either DWFX or IFC format.

- As data start being produced, it will become essential for the QS to know which cost classification to use for that particular project. Several cost standards are used in the industry and include the New Rules of Measurement (NRM) issued by the RICS as a means to cost a BIM project. However, it is not unusual to encounter some high profile clients who may have their own preferred cost plans and methods; but as a general rule the NRM cost plans will be used if no specific standards are required. The choice of cost classification needs to be made clear early on to all stakeholders as it will help the overall understanding of the QS cost analysis.

These are a few early choices that need to be made to ensure a stable basis for the project to build on. Now, as the project evolves through the different stages of design and data production grows at each data drop or upload on the Cloud system, a feedback loop involving the different consultants needs to take place where a thorough review of the data is performed. For the QS, this means reviewing the updated model in terms of what information was left unchanged, what was added or deleted, and what was modified and by who. Depending on the software platform, this data can be generated automatically either graphically and/or in a form of a detailed report that the QS can review.

Once the revision tool has been run, it lies with the QS to update the cost plan to reflect the updated design. To help with this, several features available on the different cost estimation software are at the 5D QS' disposal to render this task more accurate and less time-consuming:

- A link is established between a BIM object and its cost-generated output. Essentially the 5D QS analyses the BIM object and decides where its properties lie in the NRM cost plan. The object can either be cost as per item in the usual case of a standard composite item (e.g. a revolving glass door is classified in the Door section of the NRM cost plan with a rate as per revolving glass doors previously defined), or it can be cost as per the unit defined in the NRM cost plan (e.g. a wall is classified in the Wall section with a rate per unit of wall). This operation needs to be conducted on all the BIM objects in the model.
- Once the links between the BIM objects and their properties and the NRM cost plan are established, the quantification will be made automatically. This means several operations will consecutively take place: (1) the quantities per item or unit will be taken off the model; (2) the relevant rates will be applied to the quantities; (3) the current NRM cost plan will be automatically populated to reflect the new estimated cost of the project.
- To ensure that this process runs successfully and returns an accurate cost estimate, it is expected of the 5D QS that the rate library be maintained to reflect the ever-evolving landscape of supply chain prices. A set of rate libraries can be

programmed into most cost estimation software to adapt the rates used in the NRM cost plan to the supply chain used on a particular project.

Now, with all these tools available, it is still critical for the 5D QS to check the model and cost plan generated from it. Some quantities in the cost plan may be generated by adding or subtracting specific values like areas. It is imperative that the QS performs these checks manually to validate the cost analysis.

One interesting BIM solution – now spreading across major clients and suppliers in the industry – has the ability to decrease both the design cost and the cost estimation process by developing standardised design and element specifications. A database of BIM objects with client and/or supplier's standards enables higher productivity, accuracy of design and automatic cost analysis. In the retail market, where high levels of design repeatability occur, access to a standardised library of objects can have a major impact on design costs by decreasing from-scratch object creation and integration into the model while holding the design to client specifications. Such a library of BIM objects maintained across different projects using the same cost estimation classification eliminates the need to link the BIM objects to the cost plan after its first implementation, provided no additional BIM objects are used. This virtually means across all projects sharing the same cost library, BIM object library, and cost classification, the 5D QS only needs to carry out his cost analysis once.

The retail sector is the perfect market in which to use this aspect of BIM. The design repeatability of retail shops is a common feature across the industry as it is a way for brands to distinguish themselves with a well-known design, as well as a great way to increase design productivity. A good way to take advantage of this in the retail market is for the design team to conduct a standard model store project to fully design a generic shop comprising all the relevant disciplines' design. Every designer can conduct their data creation as if the project was an actual live project, and once the BIM model is complete the 5D QS can link it to the NRM cost plan with the cost library as described above. Now, whenever the retail client decides to go ahead and build a new shop, the design uses the same BIM objects as in the standard model store project, and the cost estimating then only consists of running the model through the pre-established links to get a full cost estimate of the project in virtually seconds. The 5D QS can then spend more time on value and opportunity. This is a great way to review the data quickly from a cost estimating point of view, and it gives virtually immediate cost feedback from the 5D QS to the different designers and the client. It is also a great tool to estimate the level of design present in the BIM model at any time compared to the generic standard model store. As an example, the cost analysis can indicate that 80% of the Security discipline has been modelled so far in terms of cost compared to the generic design. This can then be reviewed to check if it is correct.

As a 5D QS keeping track of the cost, the most important question is: who is designing what and when? And with that central question comes issues around the levels of detail (LOD) per each designed object, and where to classify this object in the NRM standards as a way of costing it – thus bringing the alignment of NRM with the Digital Plan Of Work (DPOW) to the forefront of our investigation. At Henry Riley, we are particularly interested in any kind of tool that will allow us to keep track of design data delivery drops throughout the capital delivery phase. The DPOW should allow the

5D QS to know which designer is responsible for any given object production and to what level of detail (and information) at any given stage of construction. It also gives a valuable cost classification code in the NRM (amongst others) that will help a 5D QS to build their cost estimation report. The alignment of NRM/DPOW/LOD seems to us a critical problem at the centre of 5D QS practice.

It is clear that at early stages of design, some elements are only early sketches and ideas and not enough information is known regarding their features to be able to classify these elements (not yet BIM objects) in a fully developed NRM cost plan. This brings attention to the different levels of NRM cost plans as detailed in the RICS standard documentation. Essentially, early cost estimates are based on Gross Internal Floor Area (GIFA), while later estimates are based on elemental analysis when the actual BIM objects are sufficiently designed. This is all to avoid making too many assumptions on the final design or the intent of the designers by using the proper level of cost plan at the proper level of design.

To conclude, as a QS practice keeping abreast of any new development in the world of BIM, we at Henry Riley feel confident in our ability to work as a 5D QS on any given BIM project, and we are already investigating the future of the practice in terms of 6D QS (Carbon accounting) and 7D QS (Lifecycle costing).

Chapter 14

BIM and Facilities Management

Kath Fontana

14.1 Introduction

The Industrial Strategy: Construction 2025 stresses the importance of creating benefit from the whole life of a building, stating their aspiration to create:

> An industry that drives and sustains growth across the entire economy by designing, manufacturing, building and maintaining assets which deliver genuine **whole life value** for customers in expanding markets both at home and abroad.[1]

This is reinforced by the marked movement over the last two years towards a view that BIM will provide most benefit to the client when used across the whole life of a building. The role of facilities management (FM) within BIM has been the topic of much debate, but there are encouraging signs that BIM is progressively being accepted as a key enabler for improving performance of buildings and for a transformation in the way that FM manages data. For example, BIM and Government Soft Landings are now routine topics of CPD offerings from the BIFM, and the RICS APC for facilities management includes a BIM competence. This new level of acceptance is no doubt assisted by the realisation that failure to develop capability in this area will be a barrier to entry for some Government work post 2016. Conversely, those organisations that excel in the integration of BIM Government Soft Landings (GSL) and FM should emerge as the winners of public sector construction and FM projects.

However, there are still a number of hurdles to overcome if BIM is to be truly embraced and indeed exploited in the operational phase of a building's life.

14.2 Collaboration between facilities management practitioners and other built environment disciplines

Historically, many facilities managers have been distant from the early stages of a construction project. Traditional procurement models do not facilitate the early

[1] Industrial Strategy: Construction 2025.

Construction Manager's BIM Handbook, First Edition. John Eynon.

involvement of FM supply chain into the first stages of a project. The RIBA Plan of Work 2013 notes that:

> Services required as part of on-going (long term) stage 7 duties are not listed. It is anticipated that these will be included in separate professional services contracts or operating contracts.[2]

Most often, then, the FM supplier will be engaged at best three months before practical completion. To add further complexity, many clients also outsource the management of their operational databases or Computer Aided Facilities Management (CAFM) Systems to their FM suppliers.

This poses a set of problems for the client wishing to procure 'Level 2 BIM'. Either an in house facilities manager, or most likely a consultant, will need to be engaged to support the development of Employers Information Requirements, defining the quantity and detail of information within the BIM and other systems.

This is likely to create issues later in the project when the maintenance contractor may need additional, different, or less information than they have been provided with, and may have had no input into how the data is to be managed in the operational phase. There is clearly potential here for further Information Requirement development and therefore additional cost/time for the client. A revised version of BS 8536:2010 – Facility management briefing: code of practice is in development and should provide further guidance on best practice in early engagement of FM with design and construction within the context of BIM and GSL.

14.3 Facilities management and information management

In a 'traditional' project, the handover process at Stage 6 is often unsatisfactory with a key failure being the effective handover of data to building operators. Generally, in a non-BIM project, at handover the client will receive this – from which they must provide data (typically in a spreadsheet format) to enable the FM contract to be priced and from which the FM supplier must create the asset database to enable them to manage the building effectively. The facilities manager will not be able to rely on the 'as-constructed' data handed over as it is not warranted by the client. This means that the FM supplier will want to resurvey the building and adjust their price based on the new data. This asset data risk is then replicated each and every time the FM contract is re-tendered.

During the operational phase, it is generally the case that data and information is kept and managed in a manual format. It is often difficult for facilities managers to locate accurate information about the building, and therefore diagnostics are often intrusive and time consuming. Keeping information up to date is difficult, as the high volume of day-to-day transactional activity is almost impossible to cross-reference back to as-built information. As a result, as-built data tends to become obsolete very quickly. This is a real risk to owners of complex buildings that can quickly become dysfunctional if the proper information is not available to enable effective maintenance.

[2] RIBA Plan of Work 2013.

The use of BIM, underpinned by the concepts within PAS 1192:2 and PAS 1192:3, has the potential to transform this wasteful process. Data that is verified and validated within a Common Data Environment will clearly be much more reliable. The loop could and should be closed with early FM involvement in the development of Employers Information Requirements. The structured approach to operational information management set out in PAS 1192:3 will be a major benefit to clients and to the supply chain.

PAS 1192-3 focuses on the operational phase of assets irrespective of whether these were commissioned through major works, acquired through transfer of ownership or already existed in an asset portfolio. The operational phase of an asset is deemed to commence at handover, but the requirements within PAS 1192-3 are also important in the delivery of capital works.

The creation of an Asset Information Model, as contemplated in PAS 1192:3, will be a major step forward for most clients. The Asset Information Model is a set of data and information related to a collection of assets or buildings linked together (federated) via various different electronic systems. The structure and elements of such models are flexible dependant on a business's own internal needs for asset information and reporting (known as Asset Information Requirements). Generally, though, it can be expected to contain:

- information concerning the original brief, specification, design and analysis relating to the original installation of the asset and any subsequent changes;
- 3D object-based model(s) of the environment and location of the asset ('Project Information Model');
- information, or links to information, concerning ownership of the asset and any rights or covenants associated with the asset;
- information, or links to information, concerning any data obtained from the maintenance, survey or other work carried out on the asset during its lifetime;
- information, or links to information, concerning any data obtained from monitoring the operation and condition of the asset, for example through a Computer Aided Facilities Management system.

Like the Project Information Model, the information should be managed within a Common Data Environment, and the PAS describes how this is managed. Designers and contractors should be aware that Project Information Models will be expected to integrate into a wider Asset Information Model. From a BIM perspective, the key points to note are the interrelationship between the Asset Information Requirements in PAS 1192:3 and the Employers Information Requirements set out in PAS 1192:3 as shown in Figure 14.1.

From this it can be noted that it is expected that clients will already understand their own information requirements, derived from their existing AIM and supplemented by Plain Language Questions.

14.4 Data exchange and COBie

Most facilities managers already work with databases and technology. A Building Management System (BMS) handles the operating of building mechanical and lighting

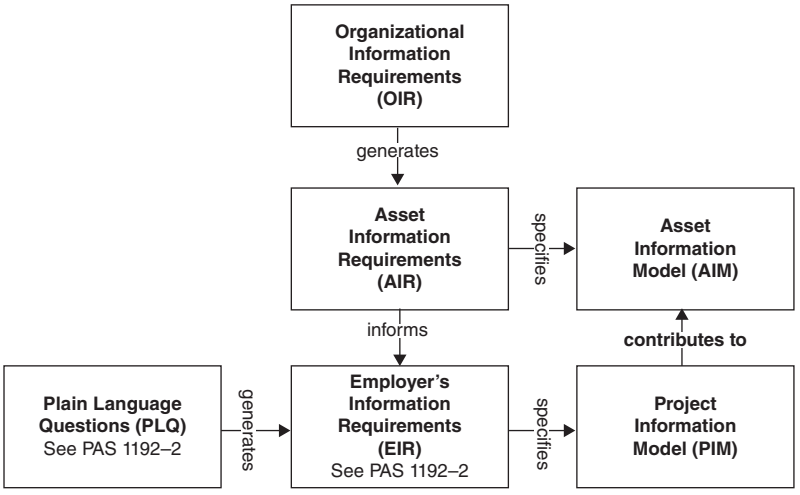

Figure 14.1 Relationship between PAS 1192:3 and PAS 1192:3 information requirements.

systems. An Energy Management System, which might be part of the BMS, handles the energy. In many cases, Computer Aided Facilities Management Systems (CAFM) support facilities management activities such as planned and reactive maintenance, work orders, procurement, space management, capital planning and so on. However, it is rare for these systems to be electronically linked or federated.

Structured data in the form of COBie has the potential to be a useful tool for facilities managers. But COBie alone does not enable the facilities manager to 'do BIM'. COBie will simplify the process of transferring data from a BIM into other systems, as at least the facilities manager will know what structure the data will be presented in, and will have had input into what data is provided.

However, clients, designers and contractors should be aware that each and every COBie dataset will need to be mapped and configured for upload into CAFM systems, for which there is no standard schema. Generally, the FM industry has not standardised in this field and so each extant CAFM system may have its own coding and naming convention system. Clients therefore need to specify within the EIRs the standards and process for this data mapping from COBie to CAFM and indeed any other systems such as BMS.

There is great potential for BIM to be a tool for optimised lifecycle management. The ability of BIM to provide operational cost estimators with detailed 3D project views and carry out quantity take off and estimating using BIM software, in conjunction with cost data, is likely to transform the process of predicting and managing lifecycle costs. To facilitate this, the revised BS8544:2013 Guide for life cycle costing of maintenance during the in use phases of buildings recommends that:

> Data should be made interoperable, for example through COBIE data exchange format, in order to ensure that existing building data is accessible to LCC of maintenance models, and to ensure that output data

> from LCC of maintenance models is accessible to other interoperable models.[3]

14.5 Government Soft Landings

The Government has mandated that all public sector work from 2016 onwards will incorporate Government Soft Landings (GSL) processes. BIM will be progressively used as a data management tool to assist the measurement activities required by GSL.

Government Soft Landings is an intrinsic part of the BIM process and is part of a wider industry move towards improving the way buildings perform over their life and will involve challenging the way we currently do things. It is based on the BSRIA Soft Landings approach that many private sector clients have already adopted. The overriding objective of GSL is to:

> improve performance of buildings by … aligning the interests of those who design and construct an asset with those who subsequently use it.[4]

The Government Soft Landings Guidance documents set out a series of processes that Government departments will be expected to follow through the life of each of their projects, and these are based around the new RIBA Plan of Work 2013. The fundamental concept of GSL is the idea of the *golden thread* of defining, measuring and delivering the building purpose from an early stage design right through to delivery and operation. Measurement activity will focus on six key themes:

- Functionality and effectiveness.
- Capital cost and operating cost.
- Environmental management.
- Facilities management.
- Commissioning, training and handover.
- Planning for aftercare.

Post Occupancy Evaluation of the required outcomes will be measured annually for a three-year period. Once again, we come across the issue of the procurement model and the fragmentation between the building contract and the operational contract. Clients will need to consider how to manage the results from a Post Occupancy Evaluation study some three years after building handover, during which period it has been maintained by an unrelated party to the building contract.

Notwithstanding these issues, the Government is reporting significant benefits from using GSL techniques. They have published a number of case studies including the Liverpool Prison Kitchen refurbishment where they achieved space savings of between 1.5% and 54% and capital cost reductions of approximately £270k (5%); and the National Measurement Office – Advanced Metrology Laboratory where they achieved an estimated 25% reduction in lab set-up times and an expected 10% increase in laboratory availability.

[3] BS8544:2013 Guide for life cycle costing of maintenance during the in use phases of buildings.
[4] Government Soft Landings Executive Summary.

14.6 Conclusions

BIM (including Soft Landings) has the potential to finally achieve the long-held aspirations of many working in the Built Environment, including facilities managers. The benefits of the new way of working are now being demonstrated in real projects. Fundamentally though, there is a need for the facilities manager to be accepted as a key part of the team. To enable this we must put in place new procurement models and invest in skills development to enable us to reap the full benefits of digital operational management enabled by BIM.

> To achieve the dramatic increases in efficiency and quality that are both possible and necessary we must all rethink construction.[5]

Five key bullet points to follow

- The role of the client is essential in ensuring effective BIM in the operational phase.
- Find a way to engage with the future FM and their supply chain as early as possible.
- Clearly define your EIRs to include how data will be managed and used in operations.
- Set out your building performance outcomes early – and make sure they are updated as design progresses.
- Make sure your building outcomes are measurable over the life of your building.

[5] Rethinking Construction 1998.

Chapter 15

Cyber Security

Steve Race

> The growth of the internet has transformed our everyday lives. But with greater openness, interconnection and dependency comes greater vulnerability. The threat to our national security from cyber-attacks is real and growing. Organised criminals, terrorists, hostile states, and 'hacktivists' are all seeking to exploit cyber space to their own ends. (Francis Maude Ministerial Statement, Cabinet office 25 November 2011.)

Around six months after Paul Morrell's declaration on BIM, Francis Maude, another Cabinet Minister based in the same department of Business Innovation and Skills, launched a further Government report. It was entitled *The UK Cyber Security Strategy*.

In the construction industry, few eyebrows were raised at its appearance; indeed it was magically disregarded by practitioners and professional bodies alike.

Maude relied on two reports, one from Detica – a subsidiary of BAE systems – and one from Cambridge University. The reports put the annual cost to UK Plc at £27bn and £18bn respectively. The figures they came up with caused some controversy because of the high value they placed on cybercrime. But even if the figures were out by some margin, they nevertheless represent a very significant cost. The reports covered all types of cybercrime including, for example, identity theft, online purchasing, cyber stalking and theft.

The construction industry did not figure very much in these findings, perhaps due to a lack of understanding of the problem and no research within the sector. Level 3 BIM, which is currently under discussion, will inevitably involve a rapidly growing reliance on virtuality and therefore a greater exposure to cybercrime.

There are perhaps opposing implications for Level 3 BIM. On the one hand there will be enormous leaps forward in terms of cooperation via integrated, but more diffuse, systems and databases in the construction industry that will rely heavily on public and private use of the Cloud. On the other hand, greater dependence on the Cloud will require a level of protection, governance, understanding and expertise that does not yet exist. Construction industry information of all types riding the virtual Cloud will be open to use, abuse and misuse.

Construction Manager's BIM Handbook, First Edition. John Eynon.

Hacking will grow into a big business, particularly because there is no global agreement on how the Cloud should be policed. All but the smallest messages are broken into small packets of information that are disassembled at the sending end, routed through servers anywhere in the world and then reassembled at the receiving end. A 3D model transmitted from one person to another in the same organisation may have visited servers at multiple international locations.

Hackers are growing in number and competence. Commercial firewall and anti-virus software are not even first training exercises for hackers. Encryption is the new challenge and already industry standard encryption techniques are no longer a safe option. Even the best anti-virus software has a 10–25% success rate in interception, let alone removal. By definition hackers are ahead of the game, whatever is invented is their next challenge. The only form of security any individual or organisation has is that nobody has bothered to attack them.

There are many spectacular examples of hacking activity. One of the most famous hacking groups is that named Anonymous. They hacked into government agencies in the USA, Israel, Tunisia, Uganda and others; child pornography sites; copyright protection agencies; the Westboro Baptist Church; the Church of Scientology; and corporations such as PayPal, MasterCard, Visa and Sony. Anonymous have publicly supported WikiLeaks and the Occupy movement. Firewalls, virus software and VPNs were no challenge whatsoever to their programming ingenuity and determination. They had their own rather warped sense of social responsibility that they felt justified their actions; some examples of 'getting round' certain governments censorship of free speech perhaps justify their activity, but causing mayhem and extreme fear for individuals does not. Anonymous represents something of an extreme in terms of cyber activity.

The other side of the coin is to counter hacking activity. Thus the concept of cyber resilience and the cyber resilience engineer comes into being. Strangely, this is the positive side to hacking. To be a resilience engineer, in other words to know how to counter the hack, you have to know what the hack is and how it operates and how to cure it; therefore, the resilience engineer has hacking capability.

Resilience engineers are a growing fraternity and many work in sensitive government or corporate environments. Some will become disillusioned by the organisation they work for, others will be tempted by financial inducement – either way the pool of hacking/resilience expertise will grow and be available for nefarious use.

How does all this percolate down into our industry in a BIM context?

The examples quoted above for Anonymous are quite spectacular but there are more mundane possibilities in architecture and construction. They are considered under the following headings, which are by no means an absolute classification of the issues involved but merely illustrate some of the possibilities of cyber abuse.

15.1 Architects Registration Board (ARB) Clause 4.3

This clause in the Architects Code of Conduct states 'You should ensure that adequate security is in place to safeguard both paper and electronic records for your clients,

taking full account of data protection legislation, and that clients' confidential information is safeguarded'. It illustrates a principle that is generally applicable to all members of the construction industry.

The operative words are 'electronic records'. Understanding of the implications of this clause in the construction courts and professional institutions is yet to catch up with the cyber world. To avoid negligence the architect would have to have done what any *reasonable* person would have done in the same circumstances. If, at the moment, the *reasonable* person were asked, how did you protect your client's electronic records? The answer would probably be, well, we use anti-virus software, we have a robust firewall and we take regular backups.

This may well currently satisfy the judges', insurers' and professional bodies' understanding of protecting electronic records, and perhaps negligence would be avoided at the moment. In future this may not be good enough when cyber understanding, regulation and wider cyber resilience techniques become more prevalent.

Although negligence may be avoided, a cyber attack may cause other types of problems that could lead to legal action. For example, if a cyber attack were to completely corrupt a project BIM based on a collaborative portal, could the project team resurrect that database, and would the cost to their respective organisations be met by appropriate insurance?

Alternatively, what about a less obvious attack that did not immediately reveal itself until someone found a couple of zeros had been added or subtracted to a fee bid, or a 'shall' changed to a 'shall not' in a legal form of communication? This type of cyber interference is just as corrosive and may lead to a more acrimonious form of litigation.

15.2 Sensitive building typologies

We often send BIM models to each other via the web these days. If these packages of information were intercepted then the implication could be very sinister indeed.

For example, if a project team was working on an MOD or airport project, that information could be intercepted and sold to terrorist organisations.

A team working on MOJ projects could have their information high-jacked and sold to organised crime. Those working on hospitals that include pharmacies might have their information copied and sold to drugs networks. Schools to paedophile rings. The possibilities are endless to the creative cyber-criminal mind.

15.3 Servers

Servers which make up the Cloud exist in anonymous server farms in supposedly highly protected buildings all over the world. The average internet user has no control over the route their information takes through these server farms.

Portal vendors or vendors offering web-based applications may use their own server installations or they may in turn buy server space from a Cloud provider.

Access to these servers is difficult, technically and legally, often terms and conditions deny ingress in which case the ability to protect your information is severely limited or completely impossible.

It is not necessary to attack information direct. Building Control Systems (BCS) that house the servers are an equal target for disruption. More and more BCS systems will have IP addresses in future. The motivation behind this is laudable. Providers will present this as a new value proposition, in that they will proclaim to be able to sense when any component of a BCS needs maintenance or replacement. The sinister side of this is that anything with an IP address is programmable and therefore open to cyber attack, and the system they are part of can be compromised, for example the ambient temperature in a server farm might be varied to such an extent that the servers fail to operate causing mayhem in information terms.

15.4 Virtual participants

There is another aspect to the forthcoming cyber world in construction that generates both exciting and worrying emotions in equal measure.

In the software engineering world there is a phenomenon called object technology. This is a piece of software that carries information and 'behaviour'; in other words, it is capable of 'doing something'. Of equal importance is that a software object carries information about relationships between things. The brevity and simplicity of these statements belies the power and influence they have on us.

Object technology nowadays pervades every aspect of everyone's lives whether they realise it or not. It is embedded in our transportation systems, white goods, social media, medical equipment, the web, the list is endless – we do not move today without using object technology.

A simple illustration with which we are all familiar is Microsoft Office Word. The symbol is the paragraph marker. It can be regarded as an object, in reality it probably involves many objects, but a working concept is that it contains information about, for example, the font type, size and colour of the paragraph, the spacing between lines of text, and very importantly the relationships with the paragraphs above and below and the sides of the page. If we click on the justification icon it does something, that is it behaves.

To extend this idea: we are accustomed to using today's so-called CAD platforms, where a light switch placed in a wall next to a door carries information about its size, location and so on and it behaves in that it maintains its relationship with the door if the door is moved.

Another important idea is the semantic web, and this situation is developing rapidly. Not so long ago we entered a query into a search engine, we received some web pages, we viewed them and we interpreted them. Now, even before we have finished our query, the search engine is interpreting what we have entered and is suggesting possibilities. It is understanding what we mean and that is what the semantic web is all about. As well as our own interpretation, the web page itself will understand the content it contains.

Extrapolating further, there are vast tracts of what we do in construction that lend themselves to these ideas of objects and a semantic web. Building regulations, planning policies, contract documents, health and safety documentation are simply information, relationships between information, and prompt us to do something.

There begin to be many consequences of this strand of technological development.

For example, the building regulations contain straightforward information, information on relationships between elements and explicit and implicit recommendations on what we should do. All this conforms to ideas of objects and web semantics. In the future, a virtual building inspector could visit a BIM environment; it would 'understand' the design and decide where it conformed or contravened regulations. The 'virtual knowledge and ability' that enabled it to do this would also give it the capacity to change the design to conform, possibly without the design team knowing. Serious questions of responsibilities and insurances arise.

Similar situations arise with the planning officer and health and safety advisor. Planning policies and H&S issues can be represented in object and semantic web forms.

In this world, the product manufacturer would be the custodian of all the information about their product. The product would contain information about itself as well as the components it might interact with. The virtual product might influence our design and provide the optimum conditions for itself – again, massive implications for responsibilities and insurances.

The most intriguing proposition is the virtual lawyer. Contractual documents of all varieties cannot escape the object and semantic web.

A contract contains legal phraseologies, time limits and key words such as 'shall', 'may', 'divergences', 'relief event' and many others. The semantics surrounding these key expressions can be scrutinised and relationships established between clauses and possibly with information contained within external software BIM platforms. The virtual contract or solicitor could be equipped with the ability to monitor, issue directions, eliminate inconsistencies between different contracts or instigate legal action if it finds a party is in breach.

15.5 The Institute of Engineering and Technology (IET) Code of Practice – Cyber Security in the Built Environment

The IET has recently published the Code of Practice for Cyber Resilience in the Built Environment. It is the first acknowledgement in the construction industry sector that this is an issue that demands serious attention, and follows on from Francis Maude's initiatives launched around 2012.

The 'Code of Practice uses principles rather than national legislation or specific standards to explain what good practice is'. Its main focus is on Building Management Systems (BMS), where they occur and connections to the wider cyber environment.

The Code is intended to alert senior management to the vulnerabilities their organisations face in an increasingly Cloud-based world. They are unlikely to be the people who actually implement a cyber-resilience strategy day to day, but they need to know the principles of cyber vulnerability and the need to include a preventative framework within the organisation.

At the same time, the Code does give some guidance to those who must execute cyber safety at a practical level.

Although the Code does highlight BMS systems, the principles it describes are equally applicable to project teams operating on server-based collaborative portals within the control of portal providers or a step beyond them, the wider Cloud.

15.6 Ending

The forthcoming cyber world, like all inventions offers opportunity and misfortune. There will be profound consequences for how we as an industry operate in the future, consequences that insist on different ways of working, new forms of legal arrangements, alternative fee, cost and value profiles, a metamorphosis of traditional roles and responsibilities, but hopefully a better built environment.

Cyber Security

- The cyber world is already here and growing rapidly.
- It has monumental implications for liabilities and responsibilities in the construction industry.
- Every organisation and project team needs to incorporate a cyber-resilience regime into its operation.
- Examine closely the terms under which you use a collaborative portal or the Cloud.
- Virtual agents will have an increasing, perhaps intrusive, influence on what we do.

Chapter 16

Level 2, Level 3 and Beyond …

Mark Bew

16.1 Introduction

Digitisation has delivered a step-change in productivity and performance across the manufacturing industry over the last two decades. But in construction – a sector bigger than aerospace, automotive and energy put together and where the technology is also applicable – productivity has flat-lined. Digitising construction is challenging traditional methods that have encouraged inefficient, single, one-off, bespoke developments with little opportunity for production runs or standardisation.

Digitisation in construction is currently referred to as Building Information Modelling or BIM. It is essentially the same technique used by the advanced aerospace industry in pre-production to design, build and test new aircraft, with all their critical components (airframe, propulsion, etc.) modelled in a digital environment to provide surety of production and to deliver 'as-designed' operational performance. BIM in the UK is now starting to take off following a two-pronged Government intervention to overcome the coordination failure described above. In 2011, the Government announced that BIM would be a requirement of all central Government construction procurement from 2016, providing a powerful incentive to firms to invest in BIM capability to remain eligible to compete for future government contracts. Second, it committed to fund a BIM Task Group to develop the necessary common standards and protocols, and to make them available in accessible formats without cost to encourage widespread take-up, especially among SMEs.

The Government's current BIM programme, known as BIM Level 2, has already achieved 20% cost savings as part of the Government's Construction Strategy for its construction procurement. The programme is on track to contribute significantly to the Government's overall saving of £1.2bn, increasing from £840m in 2013/14. The Construction Leadership Council has put BIM at the heart of its sector strategy, Construction 2025, which commits to cut built asset costs by 33% and time and carbon by 50%.

16.2 What is the BIM Programme all about?

In 2011, the Government recognised the capacity of digital technologies to reshape how we procure, deliver and operate our built environment, but was struggling to

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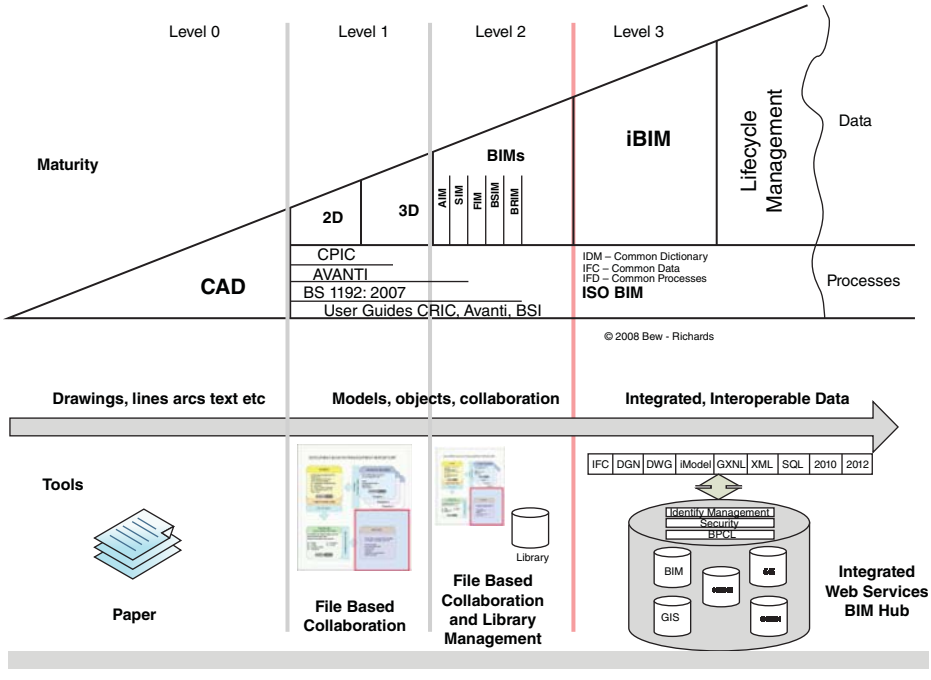

Figure 16.1 Bew–Richards maturity ramp.

understand how best to enter the market with a programme that was understandable by the roughly 3 million individuals employed in the sector, many of whom were employed by small or micro SME businesses. The need to provide a clear and progressive message and plan was embodied in the 2008 Bew–Richards maturity ramp, shown in Figure 16.1. This provided a recognisable journey from traditional drawing boards through to the open, semantic 'construction internet' required to enable the industry to be able to demonstrate its value to society.

It's probably worth reminding ourselves of these stages, their anticipated benefits and learning (Table 16.1).

The HMG Construction Strategy of 2011 demanded that 'Level 2' BIM techniques and tools (i.e. the computerisation of the design, delivery and operation of buildings and infrastructure) should be used on all public construction projects by 2016. This was followed up and reinforced in the Industrial Strategy in 2013 which set out to achieve up to 33% savings of whole life costs, 50% reduction on CO_2, 50% programme savings and 50% improvement in export performance.

16.3 Level 2

Level 2 is described in detail by a series of documents and tools that have been developed by the BIM Task Group and industry teams (Table 16.2). These documents describe the delivery process and provide detail as to how such BIM-enabled methods can be applied to projects.

Table 16.1 BIM Levels, benefits and learning

Level	Description	Benefit	Learning
0	Unmanaged CAD probably 2D, with paper (or electronic paper) as the most likely data exchange mechanism.		There are plenty of businesses out in the industry still here. It is clear that this is likely to be the case for small works and domestic scenarios for some time.
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.	We have seen good examples of Level 1 being executed well and efficiency gains being delivered. Doing Level 1 well is a pre-requisite for Level 2.	The notion that BIM is a silver bullet that negates the need to deliver effective project, design and commercial management capabilities really emerges with Level 2.
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.	Well managed Level 2 programmes bring these issues into sharp focus and give credibility to the veracity of the 20% savings we are seeing now on a repeated basis. Level 2 also has a significant benefit in that is has opened up the world of construction and BIM data to many more people than ever before.	The procurement of data is a complex and nontrivial task. Digitising the process has brought a clear methodology based on traditional techniques, which in itself brings benefits. However, having access to accurate validated data is bringing a realisation over how transparency will really drive new and effective behaviours in the future.
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.	It is hard to imagine how the specification of Digital Built Britain would have been achieved without the benefit of Level 2. The concepts of whole life cost and carbon management in terms of measurement methodologies are in their infancy, but what is clear is if there is a need to manage 'whole life' there is a need to measure 'whole life' and the possibilities opened up through the DBB and Internet of Things will make data available to open these new markets.	Level 2 has given an industry dimensioned model for the specification of an entire new commercial model based on open, transparent and transactable data.

Table 16.2 Level 2 documents and tools

Document	Description	Status
PAS1192:2:2013	This document describes the production of coordinated design and construction (CAPEX) information, it is designed to be independent of any procurement route or form of contract is used. Each task needs to be carried out in a particular order for the mutual benefit of all those involved, otherwise known as 'collaborative working'. In a collaborative working environment, teams are asked to produce information using standardised processes and agreed standards and methods, to ensure the same form and quality, enabling information to be used and reused without change or interpretation. If an individual, office or team changes the process without agreement, it will hinder collaboration – a participant insisting on 'my standard' is not acceptable in a collaborative working environment. Wherever possible, lean principles are also described to reduce the expenditure of resources for any goal other than the creation of value for the employer. The document references BS 1192:2007, which promotes the avoidance of wasteful activities such as: • waiting and searching for information; • over-production of information with no defined use; • over-processing information, simply because the technology can; • defects caused by poor coordination across the graphical and non-graphical dataset that require rework. The document clearly describes the data descriptions and processes to enable this lean delivery process. The document also deals with the decommissioning processes at the beginning of the cycle.	Available
PAS1192:3:2014	This document describes the same data and process delivery and use definitions as described above, but for the operational phase of the asset. The key focus is on the development of PAS 55 compliance operational strategies and the effective transfer of data across into operations to aid soft and effective landings.	Available
BS1192:4:2014	This document is the final development of COBie-UK-2012, which is the interim data definition for information deliveries. This has been further enhanced and developed through work carried out in the infrastructure market to develop 'COBie for all'.	Available

Table 16.2 (continued)

Document	Description	Status
BIM Protocol	A suite of BIM commercial and contractual advice documents and standard forms.	Available
Government Soft Landings	A suite of documents describing Soft Landing policy and processes to ensure effective involvement of users and operators in the development of scope, design and delivery. Also ensuring effective training and handover into operations and finally the structured gathering of Post Occupation (Operational) Effectiveness data, to enhance both the current and future assets.	Available
Classification	A structured and standardised information classification system to enable information reuse and exchange.	April 2015
The Digital Plan of Works (dPoW)	An industry standard method of describing geometric requirements and data deliveries at key stages of the project cycle, providing user-driven capabilities to produce contractual documentation.	April 2015
PAS1192:5:2015	A standard to raise awareness and understanding of key issues surrounding the need to be cautious with the exposure of data in the market and open domain, especially across the internet.	April 2015

Level 2 BIM played a key role in the 2013/4 construction cost savings of £840m, when deployed as part of the overall package of measures including Government Soft Landings, Project Banks Accounts and the consolidated forms of procurement. By way of example, the MoJ Cookham Wood Young Offenders Institution achieved an overall 20% saving, including over £800,000 during the preconstruction phase, through the use of Level 2 BIM.

16.4 The next phase: Level 3 BIM

Level 3 BIM builds on the solid base of Level 2 described above. It will enable the interconnected digital design and operation of different elements in a given built environment, thus creating the potential for greater cost efficiencies, economic and social benefits in the overall operation of the environment and realisation of further benefits that exploit the extensive high-quality datasets BIM produces, including Smart Cities and Grids. Level 3 BIM will achieve further capital savings and achieve similar benefits in savings and efficiencies throughout the life of built assets – where the lion's share of cost arises. It is critical to delivering the step-change in the performance of the construction industry to which the Government is committed through the Construction Industry Strategy Construction 2025 and as recognised in the Digital Built Britain BIM strategy document.

One of the main challenges to the Industrial Strategy – Construction 2025 is the notion of Whole Life Cost. Just what do we mean by this? How do we measure it? How do we provide and report it on our respective balance sheets? All good questions that have been addressed in the DBB strategy; however, more important than cost, is the variable that is often more poorly understood … value. To truly address the need for buildings and assets to address the needs of society we need to understand the value these assets add to the delivery of functional performance … or, as shown in Figure 16.2 from Andrew Wolstenholme's paper 'Never Waste a Good Crisis', business outcomes. These value benefits helped form the DBB strategy targets that were refined into the following key outcomes:

- ***Providing more with less*** – delivering more capacity and better public services from economic and social infrastructure with less capital investment. This means using modern technologies to get more capacity out of our existing infrastructure.
- ***Maximising availability*** – finding ways of maximising the time that facilities and networks are available to be used by the public. This means using modern technologies to continuously monitor the condition and operation of infrastructure, to intervene before problems arise and to develop better solutions for the future.
- ***Reducing cost and carbon (whole life)*** – BIM is driving (and is predicated on) the new business models and integrated supply chains needed to deliver engineering and construction services more efficiently, and requires the development of new organisations, new skills and new systems to support the new ways of working.
- ***Cost, productivity and performance gains in key industrial sectors*** – the gains from BIM will be especially significant in sectors characterised by large and complex assets such as Crossrail, HS2 and Hinkley Point.
- ***Relieving skills and materials constraints on house building*** – increasing labour productivity and enabling use of other building materials is key to

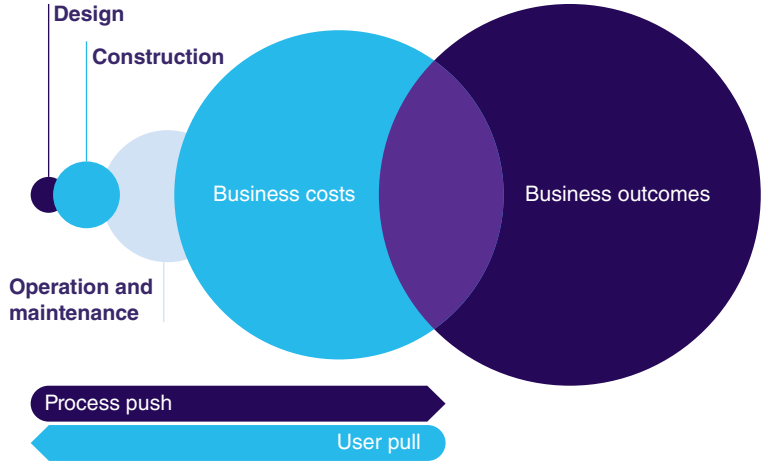

Figure 16.2 Indicative ratio of costs and value over a building's lifecycle. (A. Wolstenholme (2009) 'Never Waste a Good Crisis'.)

alleviating skills and material constraints on house building. BIM offers new approaches to design and construction, which enables, for example, large-scale offsite manufacture using different materials.

- ***Provision of new services*** – Local Authorities and service providers are under increasing pressure to provide better services to growing populations, placing greater pressure on existing and new assets. The Level 3 data will be a key market enabler and catalyst to the Smart City agenda.

Level 3 is based on the concept of the semantic web and thus allows the integration of Linked Open Data, the Internet of Things and other data services in a controlled and managed fashion. The inflexibility of moving from massive BIM files, where everything is bundled into a great big file that is too large to email or move into a collaboration system, is gone. It has been exchanged for a modern, internet friendly object-based system, that enables SME players to access all the data they need across modest communication links and equipment, with computing power being provided by large data centre hosted systems rather than individual businesses. This technology will enable effective security and data provenance services to be enabled, thus dramatically improving the ability to both trade and share data safely.

Access to valid, high-quality data from the design, construction and operational processes will, once fused with measurement data and other geographic information, provide a rich vein of intelligence from which we can begin to deliver new services and understand the value we as an industry bring. This exciting next step is tantalisingly close.

16.5 Conclusions and next steps

The UK is currently at the vanguard of computerised digital construction. We now have a window of opportunity to capitalise on our BIM leadership, secure the future of the UK construction industry and enhance the global image of our architects, designers, engineers, contractors, manufacturers and digital expertise both in hardware and software to seize work, boost employment and secure growth opportunities. If we should fail to take this opportunity it is unlikely that the standards adopted internationally for the further development of BIM would be UK ones or anywhere near as effective as those we would be in a position to develop.

The great thing about a progressive strategy is it never ends, just like evolution. We don't yet know all of the detail of what Level 3 looks like, but as it unfolds before us it is clear that whatever Level 4 may be it will be securely focused on using our new found data to help us to address the social wellbeing of our communities as they continue to urbanise and compete for the same finite resources. I look forward to coming on the journey with you.

- Are you up to speed with Level 2? If not visit www.bimtaskgroup.org and start your journey.
- How good are you at design management, project management or commercial management? If you are weak here, BIM won't help. Get help from the

CIOB and fix these gaps in your own or your business's skills base now. Take a look at the Learning Outcomes Framework at www.bimtaskgroup.org and the project management body of knowledge at www.apm.org.

- Have a plan: don't just blunder in. Understand your goals, direction and ensure you have the resources you need to deliver effectively
- Communicate, communicate, communicate … you will never do enough communication.
- Be open minded, the world is changing. We need to face up to the challenges

Chapter 17

The Next Construction Revolution

Richard Threlfall

The face of the construction industry is about to change. An industry that has until now shunned the technological revolution is about to be overwhelmed and transformed by it. Managing this change is not necessarily a costly process, but it does involve businesses envisioning the future and daring to change.

In every discussion I have in the industry, the first question I'm asked is what they should be doing, and the second is what everyone else is doing. The industry is on the cusp of a revolution and everyone knows it, but as always with a revolution pending, everyone is nervous about which side of the fence they should sit on. If the future is binary, you need visionary leadership to ensure your business does not end up consigned to the annals of history. Innovation is a necessity in order to survive.

We are now at a point where there is a critical mass of disruptive technology about to completely revolutionise how things work. Some technologies offer a step-change in efficiency in individual businesses, shifting competitive advantage; others will change the relationships between clients, contractors and the supply chain. Each business needs to think through what it believes the future will look like and then work back to the changes that need to be made today. Some of our best businesses have been thinking like this for years – innovating, investing and continually improving. But many, alas, still have their heads in the sand.

Take the photographic industry as an example. It was seen as quite progressive as the camera evolved over a century but the fundamentals were changed by the ability to capture digital imagery. Do you remember the names Agfa, Ilford and Kodak? All of them had been in existence for more than 120 years, but went bust in the last decade. Before the Second World War the average life of a firm in the S&P 500 was 75 years – now it is 15 years.

So what might the industry look in 10 years' time? Here are three models, not mutually exclusive:

- The technology takeover model. Much of the industry's future is about technology, both embedded technologies in assets and construction technologies in their creation. Building and asset management systems, Business Information Modelling (BIM), smart buildings (linked to smart grids and smart cities); user tracking systems; site-based IT and laser imaging, to name but a few. But technology is

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expensive and few contractors have the margins to invest material sums. So the value in that future industry is captured by the technology providers themselves, who eventually control the platforms and the data.
- The manufacturing model. NG Bailey recently suggested that offsite manufacture saves 35% of build cost and 40% in labour requirement. Combine offsite with BIM, embedded from the client right through to the last component supplier, and most of the value in the industry will be earned away from the site.
- The consolidation model. UK construction is one of the most fragmented industries in the world, with more than 90% of our contractors having fewer than 10 employees. It has long been recognised that this fragmentation drives inefficiency, and hence there is value to be unlocked in both horizontal and vertical consolidation. In this future, businesses will capture some of the efficiencies in BIM by buying up their supply chains and turning themselves into vertically integrated outcome providers.

Many businesses are acutely conscious of these emerging opportunities, but are unsure what to do. The structure of our industry does not give us much freedom to manoeuvre, with all but a few clients willing to support investment. Public companies in particular can find it challenging to persuade their shareholders to take a longer-term view.

But preparing for a different future doesn't necessarily involve throwing money at it. There are three things – which are essentially cost-neutral – that every business in the sector can, and should, do. They are as follows:

- Recruit those who have the vision and skills to see a different future, and take a risk by giving them a substantive say in the future direction of the business. This encompasses both hiring and trusting younger talent and hiring from outside the industry.
- Build stronger alliances with suppliers. Encourage and support their investment programmes. Put in place common systems to drive efficiencies and offset the investment costs in the partnership.
- Enter the world of the technology industries. Seek out alliances with technology businesses. Help start-ups with seed capital and access to your markets, in return for stakes in their products.

Policies like these, brought together within a strong vision, clearly articulated by the leadership team, offer the best chance – in my view – of a business coming out on top.

Any prediction is dangerous, but let me close with this one. I would be prepared to put a lot of money on less than half the current Tier 1 contractors surviving in their present form over the next decade.

Chapter 18

BIM and the Future of Design Management

Stephen Emmitt

Much has been written about 'BIM' and how the technologies and processes associated with the software will influence the way in which design and construction projects are delivered in the future. The literature is accompanied by a certain degree of uncertainty within the industry as practitioners come to terms with using new software and working in a more integrated and collaborative manner. Some of this confusion relates to a fundamental question: what does the acronym BIM represent? On the one hand BIM stands for Building Information Modelling, a set of software that allows designers to model the design in a virtual environment. On the other hand BIM stands for Building Information Management, a set of information held in one place and used primarily for the maintenance and management of a building. Often these two facets of BIM are managed in isolation using separate BIM models, which somewhat defeats the purpose. In a collaborative environment BIM should encompass both the modelling aspects and the information management aspects. BIM should be an enabler and an agent for change, and the potential for buildings to be delivered in a more collaborative way is, quite literally, at our fingertips. Karen Kensek puts it rather nicely '… BIM is more than a set of software programs. It is a process. It is inclusive, involving a large group of stakeholders from design and construction to operations and maintenance. It is collaborative …' (Kensek, 2014). As an inclusive and collaborative process it provides many opportunities to improve design management and with it the quality of our built environment.

Design management as a concept has been around since the 1960s in architecture and industrial design, but it was not until the 1990s that the larger contractors in the UK started to encompass the management of design as they took on more responsibility for the entire process of design, construction, operation and maintenance. In the early days the construction design managers were located on construction sites and primarily concerned with coordinating a vast quantity of information to ensure that the project could be built as intended. As such they were acting as a 'post-box' where (2D) information, which was often poorly integrated, and increasingly poorly thought through, was sent for the design manger to make sense of. Thus the design manager role was, and still is, a reactive role; identifying clashes, errors and omissions in the

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information; seeking clarification and further information from the designers and then coordinating prior to issuing the information to the site workers. Increasingly this role has also included the management of design changes to help deliver the project on time and on budget.

As time has progressed construction design managers have also taken on responsibility for environmental compliance. More recently the design information has started to be provided in 3D and 2D; however, problems with the quality of the information remain. Over time the scope of the design manager has also expanded, with many contractors and owners of large property portfolios employing design managers to manage design before contracts are let. Thus we have design managers with a variety of titles encompassing 'pre-contract', 'contract' and 'post-contract' roles and responsibilities. The vast majority of the design managers are still based on the construction site, but increasingly the role is moving into the contractor's main office and also into the offices of the design consultants. The premise is that by better managing the early stages of design the later stages will flow much more smoothly; the focus being on 'doing it nice, not designing it twice' to improve efficiency of design and delivery.

The expansion of the design management remit is closely related to the emergence and continual evolution of collaborative and information communication technologies. Communications with the design and delivery teams has been much improved by the use of intranet-based software programs that provide a collaborative platform for effective communication. Now the attention has turned to BIM and the opportunity to design in a collaborative virtual space. We now have the opportunity to build the building twice, first in a virtual shared model and then as a physical artefact. We also have the opportunity to plan the process of construction within the virtual model before getting onto the site. There should not be any surprises any more. We are now able to reduce the number of clashes (and one may argue that we can eliminate all clashes); finalise design information and get it signed off by all stakeholders prior to starting production; run through the effective delivery of the building before any physical work starts; agree timescales and costs with a high degree of certainty; and be certain of the intended design quality. Although this sounds very attractive, it is clearly not foolproof – as witnessed by the increasing number of legal claims associated with BIM projects that are now starting to surface. One cannot help but think that we need to change our approach, our attitude and our culture for real change to happen. This is by no means a new argument, but perhaps we can, finally, see BIM and the design manager as agents of change in a modern building industry.

18.1 Future challenges

At the time of writing this chapter it is evident that there is still a fair amount of uncertainty relating to BIM. Much of this still relates to 'Level 2 BIM' (sometimes referred to as 'lonely BIM') and it is clear that we need to move to Level 3 BIM (sometimes referred to as 'friendly BIM') and beyond as rapidly as possible if we are to work in a collaborative and integrated manner. These uncertainties include gaps in understanding, gaps in education and gaps in application; all of which will be addressed over the coming years as the construction industry (in the widest sense of the term) embraces

and responds to the new technologies and ways of thinking. However, there are challenges that lie ahead that do need to be addressed as part of the development of BIM and design management. The first relates to an appropriate 'BIM contract' and the second relates to information retrieval.

A 'true' BIM contract will need to be founded on collaborative working, openness and trust. Perhaps the closest in terms of philosophy are the project partnering and integrated project delivery (IPD) types of contract, although currently these both account for a very small proportion of the contracts executed. We urgently require a form of contract that encourages collaborative work and fully integrated design solutions. In his book *The Design Manager's Handbook* John Eynon refers to the 'two tribes' of design and construction and the need to integrate these two cultures. But the two tribes also exist within the contracting fraternity; the friendly tribes that are concerned with the quality of the built environment and process improvement and the hostile ones that use construction merely as a means of making money from uncertainty, errors and missing information. Employing BIM makes it difficult for stakeholders to hide because BIM allows full transparency of factors such as time, cost and design quality. And while it is entirely probable that the hostile tribes will evolve a strategy to continue to survive in a BIM environment, it is also equally likely that this cancer in contracting will be eradicated due to the transparency of BIM technologies. This will help to restore trust and goodwill between designers and constructors, but the currently elusive contract will also need to be there as a safety net.

This brings us back to the issue of design information. Information management is, in theory, much easier within a single BIM model compared to the old ways of producing and storing information. However, for the information to be found it needs to be coded in the correct manner. Our current focus is on coding information and associating information to elements of the building to facilitate maintenance and repair. We can very quickly access information about all aspects of, for example, a particular room in a building to facilitate quick repair or replacement of elements. What is also required, however, is a comprehensive, searchable, database of the decisions relating to the process of designing and delivering the building. This is required to help defend legal claims relating to delay and disruption, something that is currently very difficult to do even in BIM models. Integrating information communication technologies with BIMs may well resolve the data mining challenges.

18.2 What is to become of the design manager?

What of the future of the design manager in a BIM environment? The construction design manager has emerged as a new role in construction in direct response to a need from the contracting fraternity. As BIM becomes widely adopted and, one hopes, the quality of design information improves, the reactive role of the design manager will largely disappear; no longer needed on the site as the problems they were employed to tackle will no longer be present. But this is unlikely to be the end of the design manager in construction because the need to better manage design has been clearly demonstrated. Even in a BIM world, someone has to take responsibility for the quality of the design and the quality of the resultant design information. It is a widely held view

among design managers that the role will evolve into two inter-related and pro-active functions. First, to manage design activity. This will involve managing the BIM process to oversee and direct collaborative design interactions to ensure effective integrated design solutions are delivered to the client. Second, to manage the flow of design information from the designers to the producers via the BIM. It is important to point out that this is more than an information management role and is not a substitute for the technical management of the BIM software and computer hardware (BIM manager).

Picking up on the process and collaborative aspects of BIM, there will be fundamental changes for how design, both as an activity and an output, will be managed. Moving from a reactive role to a pro-active role the design manager will be tasked with setting up the design and delivery team as part of an integrated delivery protocol. Choice of the most appropriate information technologies and the selection of the most appropriate people would be central to this protocol. Once established, the focus of the design manager would then turn to the effective development of the project team to help identify and deliver the best value for all project stakeholders. In essence, the efforts of the design manager need to be on the design and delivery of an effective and efficient process; a process in which design quality is the driving force.

And so, in many respects, the design manager will evolve into someone dealing with the *management* of design rather than the coordinator of disparate design information; a more fulfilling and creative role that adds value to all project stakeholders. And this takes us full circle and back to the 1960s where the authors of the very early literature on design management argued for the need to better manage design as an activity and an output. Now we have the technologies and we also know what needs to be done, thus we can confidently look forward to buildings that exceed the client's wishes and which are delivered on time, on budget and to the agreed level of quality. It is the design managers of the future, working with the most appropriate digital technologies, that will realise our utopian dream of delivering design quality.

Further reading

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Chapter 19

BIM and Social Media

Fred Mills

19.1 The social duty of Generation Y

These are digital times.

You cannot escape it, nor fail to be affected it by it. Our lives are now conducted in an ever richer digital world underpinned by a culture of sharing and collaboration. Data and its value are continually traded in an open information economy.

The pace of digital evolution is overwhelming. Since the Industrial Revolutions of the nineteenth and early twentieth centuries, and the end of the Second World War, the rate of technological advancement has been increasing exponentially. Today's youth now grow up immersed in this environment.

Social media connects our physical, biological world with the digital one and is the beating heart of the information economy. It's the channel, the directory, the search engine, the platform, the forum, the community and the market all rolled into one. Our world today relies heavily on it. Tomorrow's world will revolve around it.

While specific social networks may come and go – and debates rumble on about the responsibility and future direction of the established big boys – social media is now part of our lives and here to stay. Much more than just a fad, it's having a material effect on the way we live our lives at the most cultural and primal of levels.

19.2 Generational advantage

While I would fiercely argue against age being any kind of factor in technology adoption – the author of this book, for example, happens to be one of the most inspirational evangelists for digitisation that I know – there is undeniably a degree of generational advantage.

Demographic analysts call generations different things and your year of birth will determine which of their boxes you fall into. Unfortunately, it really is as simple as that. Born in 1986, I am very much a part of Generation Y (also known as the Millenials). My peer group were all born between 1980 and 2000. Those born after the 1950s but before 1980 are typically termed Generation X and are the parents of most Millennials.

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They are the ones who started the alphabetical labelling system at X, giving us a serious crisis in terminology just three categories later. Thanks guys.

Those born after 2000 are known as Generation Z. They are growing up wholly immersed in this digital world and do not know any different. They are the 2 year-olds navigating their way around the iPad or YouTube, the 4 year-old running up hefty bills in the app store, the early teenagers glued to Instagram. If you thought digital momentum was building with Generation Y, just wait until this group come of age.

To reiterate the difference, Generations X–Y are akin to the English-speaking people that were taught to speak Spanish at school. Generation Z are being born and bred in Spain; they speak the language naturally because they were immersed in the culture and had to get to grips with it in order to survive. The digital adeptness of Generation Z comes naturally to them because they've known it from birth and could not imagine anything else.

19.3 Implications for AEC

So what does this mean for those of us in the architecture, engineering and construction (AEC) industries? Those of us faced with the pressure to modernise, work collaboratively, build better buildings, become more efficient and adopt Building Information Modelling (BIM)?

Other sectors went digital a long time ago and we hang out the bottom as one of the last major industries to wholeheartedly embrace this change. The influence of external factors means we're steadily catching up and the pace of our evolution is building at that same exponential rate as the rest of the world around us, albeit with what I call the 'AEC lag'.

Generation Z will only pick up the pace as they mature and come through graduate, apprenticeship and entrepreneurial routes. Operating digitally will go from being something that people 'look into' and try to learn, to the natural way that things are done.

The growing pressure to change and relentless talk of BIM is daunting for many. Going back to our language metaphor, many people in AEC feel they have been learning French their whole lives and are now being asked to learn Spanish instead. Moving into an open, collaborative, digital environment and being asked to deliver projects through BIM feels almost alien to them. Indeed, there is a degree of 'unlearning' that these individuals must go through before they can progress. Compounded experiences and decades of the traditional, adversarial industry approach have left many instinctively defensive, sceptical, secretive and competitive. Generation Z do not have the challenge of unlearning the old ways or letting go of previous conceptions, prejudices or ideals. They are free of such things.

The Generation X approach of methodical problem solving is countered by the Generation Z assumption that somebody somewhere has already achieved what you are trying to do. They'll search online and ask questions on social media; aggregating, triangulating and rating data based on source, volume, popularity and credibility until they democratically arrive at the right answer.

Sharing, asking, seeking out expertise and collaborating are all a part of their culture.

In this environment, the widespread adoption of BIM not only becomes more feasible, but completely inevitable. In time, the idea of not using digital tools, openly sharing or collaborating will feel both primitive and archaic.

I am not assigning any aversion or evangelism to the digital world toward any particular generation here. I merely make the demographically holistic point that the current ratio in AEC is heavily weighted on Generation X, with Y in a minority and Z almost non-existent. As this ratio evolves over the next 20 years – with Z continually increasing and X decreasing – the elucidating factors for going digital will only increase. It will become ever easier. Ever faster.

19.4 The Y-bridge

So this leaves Generation Y stuck in no-man's land in the middle, between two polarised generations, right? That transitory group that history will forget? Well don't write us off just yet.

I see us as the bridge. The instinctive attitudes of Generation X are so far removed from Generation Z that to jump from one to the other immediately (if such a thing were evolutionarily possible) would cause meltdown. Generation Y have the responsibility for steering and influencing the way we harness the digital world, leveraging its capability to the greatest possible advantage for our industry. The digital environment may exist all around us, but the maturing of our response to it is where Generation Y's role is critical.

For me, the focus must be on social media; the giant common data environment, emerging focal point for our lives and font of all Generation Z knowledge that I introduced earlier. We need to become much more effective at using it, while ever-pushing the frontiers of where it can go.

In 2016 – and with considerable advancements being made by protagonists such as Su Butcher – AEC are just starting to get their heads around effective use of social media as a means of enhancing business and the building delivery/operation workflows. I emphasise the word 'effective' here as there is considerable distance to travel for many organisations. True, there is increased use of the medium in our industry, but simply being able to pick up and fire a gun is no guarantee of good marksmanship. The skill set is still very much developing. Widespread maturity in social media use remains at large and that's the opportunity for influence open to Generation Y. The direction we steer the ship in is vital.

So how can we effectively leverage social media to our advantage and what are the frontiers we need to advance? For me it distils into three key areas.

19.4.1 Support to knowledge sharing

Social media is aggressively destroying the old AEC silos which saw information and knowledge hoarded for competitive advantage.

The parameters of competition have changed. Today's leading organisations are praised for their openness, their thought leadership and their contributions to the information economy. Those hoarding information for their own advantage will find

themselves applying old tactics in a new game. They're speaking French in a Spanish café.

Today, increasing numbers of AEC professionals openly share data, expertise and advice across social media in a range of mediums. While anyone can, of course, contribute anything – regardless of whether it's right or wrong – reputation, endorsement, recommendation, sharing, extent of followings and consistency all play their part in establishing hierarchy; just as they have done in our physical world for millennia.

Almost any AEC subject can be explored because 99% of the time 'somebody somewhere has already achieved what you are trying to do'. Technical advice, guidance, jobs, education, leadership, apprenticeships, health and safety, BIM, economics, architecture – the list is infinite.

Social media is playing an especially useful role in supporting BIM adoption around the world. Hash-tags like #BIM and #GlobalBIMCrew are fantastic touch points. They are the beating hearts, steering the direction of BIM development as much as they provide data on it. Freely shared guidance and how-to videos on YouTube bring the subject to life and reach out to those yet to be engaged. Why ask people to download and read a lengthy document when you can put a fun video into their newsfeeds? Why kill yourself trying to influence 30 people in a room, when you could inspire 30,000 with one clip?

There is so much to learn and the great thing about BIM is that it forces you to. No longer can we just sit in our own boxes, looking after our own bits. BIM makes us consider the independencies; how projects are scheduled, the cost implications, the impact on the environment. Now we must collaborate or die.

While social media is increasingly being used in this intelligent way, we must take it further. It must become deeper, richer and wider, engaging a more balanced demographic cross-section of our industry on a broader range of topics. We must not fear sharing our information, blurring our work/life balances, having disagreements or debating openly. Nor must organisations resist with short-sighted usage polices or restrictions on access to social platforms. Generation Y, now climbing the hierarchy, have the power to affect these changes. They have the power to implement, engage their hesitant peers and lead by example.

19.4.2 Support to the project delivery and asset management (BIM) workflows

Maturing from simple knowledge sharing with social media, to directly supporting built environment workflows with it, is a key frontier that we must expand.

BIM is now central to both project delivery and asset management in the operational phase, and as Generation Z mature it will become business as usual. We will deliver and maintain the built world we live in through continuous data transactions in an information economy.

As BIM increasingly evolves toward fully integrated, Cloud-hosted datasets (known in the United Kingdom as BIM Level 3), the beating heart of social media will play an ever more central role. Project teams will communicate across the globe in real time on their networks in a blend of public and private environments. Project and live asset management notifications will move from email to our social accounts. Independently-minded

intelligent project datasets will automatically search our vast social ecosystems for best practice, tips and those people who have 'achieved this before'. Our suggested friend lists will become tailored to those with the expertise our current projects would benefit from. Mistakes in our 3D, 4D and 5D data will be aggregated globally to form a wildly intelligent auto-correct for the built environment. The buildings we live our lives in will be better as a result and we will take a more responsible approach towards the impact they have on our planet.

Critical decisions about the future direction of all of this sit squarely in the laps of Generation Y.

19.4.3 Democratisation of built asset delivery and operation

The ultimate step in maturity will come when social media use evolves beyond AEC to engage billions of people in the democratic development of the built environment that human life is conducted in.

Building design and the slow process of stakeholder engagement, end-user sign-offs and planning approvals that so suffocate our efficiency and delivery timescales need a radical overhaul. Effective use of social media is essential; informing design decisions with directly curated and managed commentary from various tiers of stakeholders and those whom the asset is being created to serve.

Once delivered, our built assets will provide real-time feedback on operation and in-use performance to their occupants. They will democratically collate feedback from the social media of their users to forever hone the environment they offer us. That data will be fed back and centrally aggregated on a city-wide, regional, national and international level, benefitting those in other locations with similar climates, economies and demographic makeups.

The quality of our built environment will perpetually improve as our database of globally shared experiences becomes ever-more comprehensive. Social media will democratise the way our global built environment evolves. If it sounds like science fiction, take a look at the Smart Cities movement and the likes of Barcelona, Stockholm and Chicago who are already well on their way.

We as AEC can influence this area by ensuring that each environment we create does not simply stand alone but is connected to the wider grid and relatable to the contextual surroundings of the world it is built and operated in. We must tie every built asset into the Internet of Things.

Just as the future leaders of our industry will come from Generation Y, so too will the leaders of our cities, regions and the free world. Their duty will be to oversee the responsible development of these data ecosystems. Greater emphasis and recognition will be placed on our industry by governments around the world.

I have never known a more exciting time to be part of Generation Y. The ship's wheel is ours and the course is up for setting.

The future will follow the map we draw.

Chapter 20

BIM Leaders of the Future: Engaging the Digital Generation

Alison Watson

20.1 Introduction

> 'Education, in a way, dislocates very many people from their natural talents. And human resources are like natural resources; they're often buried deep. You have to go looking for them, they're not just lying around on the surface. You have to create the circumstances where they show themselves …'
>
> (Extract from 'Bring on the learning revolution', Sir Ken Robinson, TED 2010)

Children of the twenty-first century are *digital natives*. It's a term that's used to describe your average teenager who, born into the digital age, has an expectation to be constantly *connected*.

Their everyday lives are planned on Snapchat and posted on Instagram. Long gone is the phone for talking to people. No, the phone is a digital collaboration tool. Why talk to one when you can message ten of your friends at the same time? How bizarre that you would choose a one-to-one over a one-to-ten. Children collaborate. Except they don't call it collaborating. They don't call it anything really – it's a natural way of behaving to most.

So, all the hype about collaboration being critical for a successful construction industry is a little strange to most kids: 'What, you mean they don't work together already?'

And if you want to inspire the next generation to join *your* team, you should think twice about presenting your best drawings and rolling them out across the table. Scrunched up noses, raised eyebrows, frowns … that's before you even start talking.

In truth, the construction industry has a far greater problem to deal with than BIM adoption. With so few young people coming through to our great industry, it's the future of our workforce that we should all be deeply worried about.

Practically every day, the media screams of skills gaps, gender issues, poor careers advice and failing apprenticeship programmes and, what's more, industry screams right back with 'We're doing loads of stuff to get young people interested in our sector. What more can we do?!'

Construction Manager's BIM Handbook, First Edition. John Eynon.

How the so-called 'skills gap' situation has been allowed to get so bad is beyond belief. No one saw it coming? Really? As a child, I was reasonably bright with a stonemason for a father. Every day he worked on building sites and yet I don't recall a time when he sat me down and said 'Tonight we're going to talk about abutments, aggregates and architraves, as I see a bright future for you in construction.' Girls didn't have those conversations. I'm not even sure that boys did, unless they were going to follow in Dad's footsteps.

At school, the building trade was only for boys of 'lower academic ability'. Not a lot has changed there then. The really bright ones went on to study law, finance and medicine, just like they do now.

The skills gaps was emerging, and we did nothing about it then, and seem to be doing very little that is truly effective now. That gap has since become a national crisis.

The British construction industry is experiencing one of its most exciting times, given the use of incredible technology and demonstrable global leadership in BIM it should be at the top of young people's lists as a career destination, and yet we have never experienced a more miserable time when it comes to attracting fresh, young talent.

We have to think longer term. In the words of the famous phrase 'Never let a good crisis go to waste', we should be looking to change our existing behaviour and the image we have long portrayed, rather than trying to quick fix the situation with a little government scheme here and a new careers website there.

20.2 Time flies: how six years can make all the difference

In October 2010, 13 year-old Accrington schoolboy Dan Rollings volunteered to try a new scheme to introduce technical and professional construction careers in schools. He didn't know anything about the construction industry, and took part because it meant he could skip a few Games lessons.

The 'Class Of Your Own' scheme was developed to prove that young people could collaboratively design, engineer and construct a small building using industry standard BIM software. With support from some really enthusiastic local professionals, Dan worked with some of his classmates to model the very first Eco Classroom using Autodesk Revit – and the rest is history. The Accrington Academy Eco Classroom won an international design award that took Dan and his friends to San Jose, California, and they returned to apply for planning permission, which was granted. Had it not been for losing the opportunity to be considered for public funding, the school would have built the project.

Today, Dan's love of buildings has never wavered. He progressed his design skills and, at 18 years old, was given a conditional offer to study Civil and Structural Engineering at the University of Sheffield.

Around the same time in 2010, the Government Chief Construction Adviser, Paul Morrell, in an effort to cut construction waste, publicly advocated the use of BIM where all parties working on public sector projects shared 3D design information. They were to *collaborate*. The Government Construction Strategy, published in May

2011, went on to state that the '… Government will require fully collaborative 3D BIM as a minimum by 2016'.

As for the children at Accrington? They were already working together in 3D. They queried the need for rules and regulations to 'make' people do it.

'We live in a 3D world, so *why* would you design in 2D? And *why* don't people share information? That's just stupid.'

So here we are, now in the golden year 2016. The NBS National BIM Survey 2014 results showed BIM adoption was accelerating: 54% of respondents said they had used BIM on at least one project in 2014, up 15% on the previous year. In 2010 only 13% of respondents were using BIM and 43% were entirely unaware.

Perhaps it's time to get back to basics. Perhaps we're trying too hard and can't see the wood for the trees. While we're investing in BIM as an industry, we should surely invest in teaching for a modern built environment. I'm not suggesting that every child emerges from secondary school spouting PAS 1192, but certainly we could take better advantage of young people's digital, collaborative skills that we're so lacking in the real world of work.

20.3 The challenges in engaging the Digital Generation

'The future depends on what you do today.'

(Mahatma Gandhi)

A captivated audience of 13 year olds stood watching a video of some stunning architectural visualisations on YouTube as part of a school Options Evening presentation. Parents were equally enthralled, staring at the screen with expressions ranging from awe to bewilderment, and thoughts of 'My goodness, can this be construction?!' running through their minds.

The silence was broken by one mother, asking:

'So, is this a Level 2 or a GCSE qualification?'

When told it was officially a Level 2, but included as one of the Government's new equivalent vocational qualifications, she promptly took her son by the shoulders, said, 'Thank you, we're not interested, then', and marched him out of the classroom, much to the clear disappointment of her child.

This parent's lack of understanding of the current political landscape in terms of vocational and academic qualifications is by no means unusual, and is, in fact, a major challenge for industry. So many changes have taken place in the past few years that parents, and educators, can be forgiven for thinking that anything 'vocational' applies to trades and crafts. Bearing in mind that teachers need a degree to teach, they have little understanding of alternative routes into professions. Google the words 'vocational qualification' and a range of results are thrown back, including:

'What is a Vocational Qualification? These qualifications are all about the world of work, across the full range of jobs, industries and professions. They are all the qualifications that are not GCSEs and A levels (GCEs) which are known as academic or general qualifications.'

The *Accredited Qualifications* website displays a picture of a hard hat as soon as you land on it, and opens with: 'Vocational qualifications refer to work-related qualifications. They are designed to enable the learner to acquire knowledge and skills that are required by the national occupational standards (NOS) to be able to perform a particular job.'

To the average parent, university does not spring to mind when 'work related' is in the jargon. 'Work' is about employment and ultimately financial gain; something one does *after* university, not before. Those parents and teachers who believe their children/students may not make the grade for university, often incorrectly deemed to be low(er) achievers, may well encourage their offspring down the vocational qualification route as they see them in a job as soon as they leave school, perhaps via an apprenticeship …

Carry on Googling, this time looking at the word '*apprentice*', and you get this from the *Oxford Dictionary* website:

> A person who is learning a trade from a skilled employer, having agreed to work for a fixed period at low wages.'
>
> Example: an apprentice electrician, an apprentice barman.

The *Concise Oxford Dictionary* (a trusty Ninth edition, published in 1996 and 'the foremost authority on current English') provides examples: 'apprenticed to a builder, apprenticed to a hairdresser'.

All the above are honourable trades, but again, you can forgive parents and teachers who steer their gifted and talented high achievers to take the degree option and ignore these *new-fangled* higher apprenticeships.

The unappealing, low-level perception of the vocational qualification, coupled with that of the construction industry, makes it a ginormous challenge to bridge the skills gap. Only last year, a survey by educational organisation the Edge Foundation found that youngsters were being actively discouraged from opting for vocational education by parents and teachers, who regarded them as 'too clever' to pursue a career in construction.

Paul Sperring, Associate Director at Mott MacDonald, knows that thousands of students graduate with engineering degrees each year, but finding apprentices and graduates to work in the building services sector is challenging. 'Part of the reason is that the majority of the population don't know what building services engineers do. This includes teachers, parents, careers advisers, and engineering graduates. Great buildings are designed by great teams of people, and those teams include professional engineers.'

Professional bodies and membership organisations are trying hard to rebrand construction and engineering through major campaigns, but all the PR and marketing in the world will not help to educate parents and educators unless a campaign is in conjunction with, and clearly supported by, leading government figures, especially those in the Department for Education.

Are the politicians really listening? One would hope so, but industry leaders could do more to ensure that the message being delivered in the Department for Business, Innovation and Skills is also being heard around the corner in Sanctuary Gardens, the

home of the DfE. Nicky Morgan, Secretary of State for Education, is recently quoted as saying:

'At the heart of the failures in our education system was one simple fact – this country was failing in its duty to nurture every young person's unique talents – of letting too many future Stephen Hawkings, Mary Beards or Tim Berners-Lees leave education without realising their potential.'

Who knows, the young boy who was ushered out of the classroom at Options Evening may well have gone on to be the next Isambard Kingdom Brunel. We shall never know unless his mother hears, from Nicky Morgan herself, that the DfE's qualification reforms aim to better prepare pupils for life after school, and that she can be assured that a Level 2 qualification that appears on her 'high quality list' is one in which she, and her son, can have great faith.

The DfE's website introduces qualifications designed with, or approved by, employers which lead to 'some of the fastest-growing and most rewarding jobs of the future'.

'For example,' it quotes, 'someone interested in construction could, between the ages of 14 and 16, alongside their GCSEs, take a certificate in *designing, engineering and constructing a sustainable built environment*.'

Heartening news that 'high standard, high value' Level 2 qualifications are include in 'Progress 8' measures in secondary education and perhaps news of degree apprenticeships will also help to bring the vocational and academic battle to a close, particularly when they include chartered surveying, digital technologies and construction.

Before you get all excited that a brand new, genuine *industry derived* curriculum has finally cut the mustard, and that apprenticeships may be getting the recognition they deserve, there is still much work to do.

As BIS launches the Digital Built Britain strategic plan with an inspiring introduction …

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

… so too does the Digital Skills Committee, led by the Head of Ofqual, Baroness Sally Morgan. Entitled 'Make or Break: The UK's a Digital Future', it has similar motivations.

The introduction reads:

> Digital technology will challenge traditional methods of delivering education, meaning schools and teachers will have to adapt. New models of learning – such as increased online learning and employer-designed short courses – need to keep pace with evolving technology and digital change. Changing demands from firms, consumers, students and communities mean that apprenticeships, vocational qualifications and degrees need to deliver more general – and also specific – digital capabilities. Adults need more opportunities to learn throughout their lives to adjust to a world changing in ways as yet unknown. Education needs a greater emphasis on providing every citizen with adaptable digital skills.

Transformation. There's so much to look forward to if you have the infrastructure in place to deliver.

It is here that industry and education are poles apart. BIM is not about software, but most organisations know that they're going to need to crank up their technology if they're still using that old kit that runs Autocad LT. Whereas education is investing in programmes of study to develop coding and computer science and spending significant sums on Raspberry Pi kits, 3D printers and tablet computers, the heavy hardware needed to run anything more than a game or simple app is taking a back seat. As such, countless design technology departments (where anything remotely design and engineering based is taught) across the country are reliant on the goodwill of teachers and technicians bringing in their own laptops from home, or indeed using one of the only higher end (and this is an overstatement) laptops in the entire school to print that 3spd chess piece or access Google Earth.

One of the recommendations states:

> New and existing teaching staff need significant contact with industry to see the latest technologies in action and subsequently pass such knowledge.

No matter how significant the contact, it's hard to pass on knowledge without the most simple of technologies – a half decent computer. When many of our tech savvy youngsters have better computers at home than they encounter in school, Government must provide guidance and financial support for schools to ensure they invest in the right tools for the job. There is something about the 'one size fits all' procurement process that has very little synergy with the aspirations of the Digital Skills Committee. One school would not have had the technological ability to run the Design Engineer Construct! programme, despite being hot on the subject of architecture, if they hadn't been in the right place at the right time when Costain were disposing of their redundant laptops. We shouldn't have to rely on hand-me-downs, but then again, this second-hand kit was better than anything in school. Shameful? Maybe.

20.4 In conclusion: less is more

> 'If you make listening and observation your occupation, you will gain much more than you can by talk.'
>
> (Robert Baden-Powell)

As a justifiably proud industry, we have some unbelievable projects to show our young people just how great British construction and engineering can be. The trouble is, we can roll out Crossrail as many times as we like, but your average 12 year-old isn't so impressed.

'It looks cold and damp.'

'It's dirty.'

'It looks like loads of people just stand around all day.'

'It looks like a boring job.'

'It's not for girls.'

'Going down the creepy tunnel in the dark would be cool!'

Perhaps this is not the response we'd hope for, but that last statement says everything. Let's remember, secondary school *children* are exactly that. Children thrive when they can use their imagination and it's up to us to fire it up. If we want school children to put our industry at the top of their lists, we need to think like them and *get creative*. That way, construction becomes fun and exciting and before you know it, digital construction starts trending in the classroom, as well as on Twitter.

It's very difficult to offer constructive criticism to industry practice in schools where *student engagement* is concerned. There must be thousands of ambassadors around the country, and many of these dedicated, passionate people have the full blessing of their companies to take as many as six days off work to engage in school and community focused activities. This is fantastic on the face of it, but as business starts to boom again, and that project needs completing or that tender deadline looms closer, this is sometimes a big ask of staff. When employees are so committed to the job in hand, one could argue that it may actually put unreasonable pressure on those same individuals.

My suggestion that a deeper understanding of the industry on the part of young people may actually come from doing *less* may well seem like a strange approach – after all, it looks pretty good to have ticks against the large numbers on your Corporate Social Responsibility or National Skills Academy report – but what have you actually achieved? Practically every medium/large built environment organisation, and an awful lot of small ones too, engage hundreds and hundreds of school children throughout the country in careers talks, STEM fairs and mock interviews. There are few children given the opportunity to go to school the next day and say to their teacher, 'So Mr Jones, let's pick up where we left off yesterday and continue the discussion around building services engineering and carbon reduction …'

Imagine what might happen if they *could* …

If a regional office of each and every one of those organisations fully integrated with just one school each, honing their efforts on their teachers, then together – *collaboratively* – we will create a nation of attentive, confident, excited, re-energised educators, not to mention students.

The reader should be in no doubt that developing longstanding relationships with schools, especially those in challenging and deprived areas, can significantly raise children's aspirations. Take Clacton Coastal Academy, serving the Jaywick community among others. Jaywick didn't have gas, electricity or even a sewerage system until the 1990s. 'It's moved on,' says Head Teacher, Tracey Hemming, 'but we've got a whole area in Britain of deep deprivation and deep poverty.' This social decline is mirrored in Clacton's dilapidated housing, and the sobering facts that 54% of its population are on benefits and 33% are unemployed.

However, the Royal Institution of Chartered Surveyors has brought tangible benefits to Clacton Coastal's students. 'Spending time with professionals opened up their eyes to the many opportunities in construction and engineering,' continues Mrs Hemming. 'It moved them away from the celebrity culture and pie-in-the-sky aspirations.'

It's not rocket science. It's opening up to the suggestion that the great stuff you have been doing for the last 20 years may just need a new direction. That *together*

is better. You'll still win bids, even if it appears you're doing the same as everyone else, including those you are competing against for that aforementioned tender. And why will you win? Because you are also now striving to be the best to demonstrate the social value you bring to a project. Your sustainability and CSR policies are returning *tangible* results with evidence of delivery – not just in young people achieving useful qualifications, but also in improvements in social standing, confidence, self-esteem and happiness. Yes, happiness. A visit to the classrooms where those high standard, high quality qualifications are being taught undoubtedly leaves ambassadors with a smile on their faces. They are happy places, buzzing with activity, especially when someone from industry is not only supporting delivery of a Level 2 unit, *but breathing life into it*.

Indeed, the *personal* reward of focusing on the one school, rather than the many, is great. Not only a feeling of intense empowerment, knowing that those young people are really *learning* from what you say and do, but also the immense satisfaction that the teachers in *your* school are passing on a genuine working knowledge to their students. Those students then pass this onto their parents, and suddenly the dinner table talk is of the great structures they have learned about, their aspirations for a career in the industry, and 'Mum, did you know that the slope of a roof can be calculated using Pythagoras theorem?'

By *adopting* a school as your own, you have done a truly remarkable thing. You have connected with young people, they know you're going to return, and suddenly, *they are thriving*.

Thanks to you, the construction industry is winning the battle and forging the strongest of bonds with education. In just a few short years, that teenage talent you supported is landing on your doorstep with a CV to be proud of. Better still, they are instantly employable, and you know this for a fact. Why?

Because you moulded them to be work ready. You shaped them to what they have become.

They are the BIM leaders of the future, thanks to you.

20.5 Five things to do today if you want to change the future

1. Encourage your boss to Adopt a School. And if you are the boss, do it anyway and give you and your staff a break.
2. Call some of your competitors. Encourage them to do the same.
3. Visit a school that is doing well with vocational programmes. There's nothing more inspiring than spending time in a lesson with the next generation of AEC professionals. Encourage the school to invite some parents along at the same time, and talk to them about their hopes for their children.
4. Send an invitation to your local MP to observe the impressive progress of children undertaking these technical vocational programmes of study, and ask them to stay longer than the obligatory 15 minutes.

5. Feel good about what you stand for and what you do. And give yourself a pat on the back for doing it.

Further reading

Accrington Academy Eco Classroom students – live at CEFPI, San Jose, USA https://m.youtube.com/watch?v=mJYeNMWnOKk

'Bring on the learning revolution'. Sir Ken Robinson, TED 2010 http://www.ted.com/talks/sir_ken_robinson_bring_on_the_revolution

Clacton Coastal Academy https://sites.google.com/a/aetinet.org/clacton-coastal-academy/

Crossrail http://www.crossrail.co.uk

DfE Vocational Qualification reforms https://www.gov.uk/government/news/top-quality-technical-and-vocational-qualifications-announced

Designing, engineering and constructing a sustainable built environment qualification http://designengineerconstruct.com/what-is-dec/

DfE Progress 8 measure https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/285990/P8_factsheet.pdf

Digital Built Britain http://www.digital-built-britain.com

Government Construction Strategy 2011 https://www.gov.uk/government/publications/government-construction-strategy

Make or Break: The UK's a Digital Future http://www.publications.parliament.uk/pa/ld201415/ldselect/lddigital/111/111.pdf

NBS National BIM Survey 2014 http://www.thenbs.com/topics/bim/articles/nbs-national-bim-report-2014.asp

Oxford Dictionary: Apprentice *http://www.oxforddictionaries.com/definition/english/apprentice*

RICS and Clacton Coastal Academy http://www.rics.org/uk/the-profession/how-you-can-contribute/adopt-a-school-for-the-design-engineer-construct-programme/

The Edge Foundation http://www.edge.co.uk

Vocational Qualifications *http://www.awarding.org.uk/about-qualifications/what-is-a-vocational-qualification http://www.accreditedqualifications.org.uk/vocational-qualifications.html*

Chapter 21

Getting Started – BIM Implementation and SMEs

John Eynon

21.1 Eating the #BIMelephant!

SMEs are the lifeblood and engine room of the construction industry in the UK. There probably isn't a project anywhere that doesn't have some involvement from SMEs, and for most projects they could well make up the majority of the supply chain including design consultants.

So, when it comes to BIM, what actually is all the fuss about?

Is it really that expensive, tricky or difficult to make the transition?

Well that depends … You could even be doing BIM already and not know it … that's allowed!

In this chapter we will review a few resources that will help you work out where you are and then actually begin to take the first steps in making your own specific BIM plan, and then beginning to move along.

21.2 Resource number one – assessment and BEP

Take a look at the CPIc website and follow this link:

http://www.cpic.org.uk/cpix/cpix-bim-assessment-file/

In brief, this form will help you assess your own capabilities and also those of other organisations or businesses that you work with. This information can then be input directly to the formation of the BIM Execution Plan, which has another template on the CPIc website which, when completed, outlines how BIM is to be implemented on a project.

Don't be put off by some of the terminology, use the Dictionary and Acronym appendices. BIM has its own language to some extent, but once you get into it, it's no problem. There are plenty of people who will help you out! See below …

It is critical at the start of any project where BIM is going to be used to understand the capability and proficiency of all the teams and organisations that you will be working with. Using the assessment tool and working through developing the Project BIM Execution Plan will help you to identify any issues at the outset that can then be addressed.

Construction Manager's BIM Handbook, First Edition. John Eynon.

Remember that it is far easier to agree these items at the start than 6 or 12 months down the line when the project is in full swing and it isn't working out!

21.3 Resource number two – Task Group website

Check out the UK BIM Task Group website:

http://www.bimtaskgroup.org

Here you will find all the latest news on BIM in the UK, including standards, guidance, case studies and much more.

21.4 Resource number three – the BIM cube

Go to http://www.ciria.org/bim/cube.aspx

The BIM cube is the work of the Technology Alliance, which is a group of the software vendors all working together.

It will help you answer these questions:

- Where do I/we fit in?
- What do we need to do?
- What tools do we need?
- What skills do we need?
- What training do we need?
- What are the benefits of this?
- How much will it cost?

The cube website provides its own guidance and background information, which we won't duplicate here, but in summary you can use the tool as follows:

The cube matrix breaks down all the stakeholders as follows:

Client/Owner, Architect/Designer, Engineer/M+E, Cost Consultant, Planner, Programme Manager, Main Contractor, Specialist Contractor, Manufacturer/Supplier, and Asset/Facilities Manager.

It also breaks down the phases of a project into the main distinctive phases: *Preparation, Design, Pre-Construction, Construction, and Use*.

Using the matrix, you can look at *Activities, Toolsets, Training and Education, Benefits, Upgrade Costs, Summary*.

1. **Activities** – Use the tool to identify your role and where you take part in the project process. This will tell you what BIM activities you need to do.
2. **Toolsets** – Locating yourself on the cube in the same way will tell you what BIM tools you need to do the activities you've identified.
3. **Training and Education** – Again, just locate yourself on the cube, and this will identify the training you need to use the tools to do the activities.
4. **Benefits** – In the same way, the cube will help you to identify the kinds of benefits and efficiencies that you can expect to achieve from adopting BIM. Naturally it will take a while to become BIM proficient, perhaps over several projects.

5. **Upgrade Costs** – Health warning here: this section of the cube will help you understand your level of usage, and the order of costs involved per seat on a yearly basis. However, this is only an indicator of cost. If you're a Power user, then you will be authoring models and data, which is the most intensive use. At the other end of the scale, if you only need to view information then some versions of the software needed are free to download and use.
6. **Summary** – Summarise all the above onto a sheet and you will have the start of your own BIM plan. You will now know the activities, tools and training you need, together with an idea of cost and the potential benefits created. This summary could be the starter for discussions with, say, a software seller or advisor, or your own team. It is important to understand what you want to get out of BIM, and why you want to use BIM. This all helps to make your business case.

21.5 Resource number four – support

There are plenty of people out there who will gladly talk with you about BIM.

The BIM Regions (Regional Hubs) are a national network of local groups. They are the national, independent, not-for-profit network providing BIM support and awareness, opportunities for peer networking and promoting UK BIM Level 2, and were founded by the BIM Task Group in 2012. Details can be found here: www.bimregions.co.uk

Check out the other BIM4 groups on the BIM Task Group website. There is definitely one for you! http://www.bimtaskgroup.org.

- Look under BIM Partners.
- BIM4SME, the BIM4 group for SMEs – www.bim4sme.org. They hold local workshops, get in touch for more details.
- There are other BIM groups as well, such as for Retail, Clients, Infrastructure, Data Centres and so on. Again, just look on the Task Group website
- If you use Twitter look out for the *#UKBIMCREW* hash tag. Anyone using the handle will be happy to give some advice.

21.6 Conclusion

If you're thinking about BIM in your business or for your project, the tools we've discussed will help you focus and articulate your thinking. And remember – you are not alone. There are plenty of people out there willing to help.

21.7 As for the #BIMelephant! … !

Elephants are large, wonderful creatures. However, if you were given one on a dinner plate you would wonder where to start. It could be a daunting meal.

As with starting out on your BIM journey. There is no doubt that working in digital environments using all kinds of tools and technologies is going to revolutionise the

way we work, what we do and the results we deliver. There is so much we could do, there is so much to consider.

However, start small. Take baby steps. Don't be too ambitious. Don't get too frustrated at progress to start off with. Once you are getting used to processes, tools and terminology then push on. But always remember this is a journey, yes it is a step at a time, and we are all learning here. And one day in the near future you will realise that you've eaten the elephant and will be looking for the next one.

Chapter 22

Afterword: BIM, Digital Life and the Third Industrial Revolution

John Eynon

John Eynon on evolution, big data, Generation Z, and why for our industry the drivers for going digital and adopting BIM lie more outside than within.

22.1 The pace of digital evolution

I must be getting old. I'm approaching the big six zero in a few years time. I am perhaps your typical Baby Boomer, born in the late 50s. All this technology stuff? I've seen it happen within my lifetime!

Calculators, fax machines, mobile phones and personal computers: I've seen the first versions come out and rapidly become obsolete. I got up early to watch the first moonwalk on our black and white TV in 1969. Do you remember the ZX Spectrum? Commodore 64? Amstrad PC? Apple Macintosh? Betamax and VHS? O2? Vodafone? Well I remember Mercury 121! (An early mobile provider in the UK, now long extinct.)

And then there is the internet, email, Twitter, Instagram, Google+ and the whole plethora of media and information channels we consume daily. Facebook at over 1.5 billion users and only founded in 2004 is vying for largest nation in the world with China and India. Twitter at over 500 million is still larger than the USA.

Feel the speed of change: frightening, exciting!

And then there's the technology. Computers once filled a football stadium. The first Mac I bought had 4MB RAM and a 40MB hard-drive (that was 25 years ago. Ouch!). Nowadays I carry 64GB in my pocket on my iPhone. The Apollo 11 command module computer had 64KB. And then of course there's the whole migration to mobile from static PCs. Increased use of tablets, smartphones and wearable/implanted tech, the latter which in time will surely catch on. We are no longer tied to our desks or offices, or even anywhere in particular. The world is our oyster thanks to 4G and smartphones and online information 24/7.

And my point is? The pace of this evolution.

It's getting faster. Transforming our lives as communities, nations, the whole world, not only just as individuals or industries. Perhaps music is the most recent example,

Construction Manager's BIM Handbook, First Edition. John Eynon.

where the advent of MP3s, iTunes and the like transformed how music was produced, distributed, accessed and sold. Economic models were changed as suddenly musicians were brought much closer to their audience. The middleman could be easily bypassed.

22.2 What does it mean for us?

Other industries migrated to digital long before architecture, engineering and construction (AEC). We are perhaps the last major industry to make this journey. Moore's Law dictates the doubling of processing power and the halving of cost about every 18 months or so. The computing power at our fingertips and in our pockets is way beyond the wildest dreams of our forebears.

Our lives have been digital for many years, perhaps we just haven't really realised it. Take the whole world of Electronic Point of Sale (EPOS), and the handling of our banking, transactions and buying patterns. Travel is another example. Using Big Data machines, corporations have for years been analysing our digital footprints to profile our spending patterns and lifestyles.

So here's the thing. I believe that the reasons and drivers for our industry to move to digital – BIM and Common Data Environments – lie more outside than within.

We have seen our whole lives go digital, affecting all aspects of what we do and how we live. If you've come across the Internet of Things (IoT) or Everything (IoE) then you will know that all around us machines, objects and sensors of all kinds are communicating and sharing data, in most cases to make our lives better. But not always.

Estimates differ but I have seen figures such as '16 billion devices' projected to be connected on the IoT by the end of 2014 (which was 20% up on 2013), '50 billion' forecast by around 2020, and 'one trillion' somewhere between 2030–50. When you bear in mind that over the same period the world population is only projected to rise to around 9 billion people, that's a lot of devices and information.

The Smart City movement around the world shows how digital life works on an urban or national scale. Sensors embedded in all sorts of things and objects share data about our surroundings, from the weather, environment, traffic queues, people movements, energy and carbon consumption to the time we're coming home so that the house will fire up its systems in time for our arrival.

For all of these reasons and more, migration to BIM for our industry and the like is absolutely inevitable. For the AEC industry or the AECO industry as some now call it (architecture, engineering, construction, *operations*), then BIM and CDEs provide the missing link that joins us up to everything else. As the built environment moves into the digital age this connects us to all the other digital communities. We can no longer remain an analogue island in a digital sea.

Moving our industry into digital and BIM makes all of the above things possible; joining up buildings, assets and infrastructure, both individually and on an urban, national and even international scale. BIM isn't about a single building or asset. No more than

it's about just design and construction. It's about how we live in the built environment and share and use information about absolutely everything.

In my mind this is the democratisation of our industry. If you have the right skills or the right team with BIM tools in your hands and data at your fingertips you can achieve amazing things. You might be an engineer, or an architect, or a client or a subcontractor … but *it won't matter, and you won't have to be …*

We will see a blurring of roles, moving across the traditional silos and boundaries. As an industry we can get hung up on roles and titles, in the future this won't be so important. With BIM data and tools easily accessible this will revolutionise our daily work.

22.3 The Third Industrial Revolution

Do you hear the clock ticking? Or the distant roar of the digital tidal wave approaching? It's inevitable, irresistible and, in a way, totally consuming. Analogue ways of living and working will be toast, and so will anyone who tries to resist! For some time I have believed and stated that this is a Darwinian moment for our industry. Those that refuse to get on board with this, or are too slow to adapt, will in time go out of business or just be left behind. Businesses and careers are at stake here. Individually, if we don't acquire the digital skills appropriate for our current role in the next few years, the unemployment queue beckons.

The First and Second Industrial Revolutions were about moves towards manufacturing, mass production, and the use of steam for powering factories and travel. The Third Industrial Revolution – that we're living in the middle of, right now – is about the information economy. How digital industries and information are changing our lives. It runs from the individual to the global and informs everything in between. We are all trading, consuming and using information and data all the time. Interestingly, who makes money from your information? Think about it. (Most of the time it isn't you.)

22.4 'For Generation Z … it's as natural as breathing'

Of course, as much as we talk about technology, it's actually all about people. As a Baby Boomer I'm relatively digitally literate, but I have my limits and I encounter them every day! Looking to the younger folk around me, I can see those that have known this stuff all of their lives, because it has always been there for them. And now we have the Gen Zs and beyond growing up in this digitally savvy information soup that we call life. They are the Makers and Coders. They will change our ways of living and working and our industry as a consequence in ways that we can't even begin to imagine. The whole digital information age thing is just part of their DNA. It's as natural as breathing. Sharing information, trading information, collaborating online, networking, blurring the boundaries between private and public, work and social. It is literally all up for grabs.

Inevitably, as a Baby Boomer, or even an ageing Gen Y, you might feel past it or be feeling the heat. Don't give up. Keep up! Run faster! Get ahead!

Like I said, I am getting old. But I can honestly say that I don't think I've experienced a more exciting time in my career. There is so much going on, our industry is under all sorts of pressures and influences to change in all sorts of ways: carbon, energy, technology, climate change, diversity, equality, skills, training, education, institutions and much more. BIM is an important ingredient in catalysing change. It's just like a gripping thriller you can't put down, you want to see how the story unfolds … at least I do anyway! There is so very much more to come, we have barely scratched the surface.

22.5 2016 and beyond

We must not underestimate the digital impact on our lives, communities and work. This has barely begun.

As for BIM in the UK, the April and October 2016 deadlines approach and while in theory the target might have been met for some of the leading Government departments, outside of Whitehall the picture is very different.

Dropping down a level to Local Authorities, we have a mixed picture. Some forging ahead, building BIM requirements into their tenders and procurement, while others have not even started the journey.

The private sector is even more patchy. Several major contractors now have in place BIM processes and teams. Although how much of this is media and PR, as opposed to real implementation, process change and resulting in real benefits, remains to be seen. However, there are beacons of excellence out there, and many have at least started the journey.

Supply chain and upskilling SMEs remains high on the agenda, and this is where the action will be for several years to come, in achieving consistency of Level 2 adoption across the industry.

If we are simply implementing the 3D aspects of BIM, plus some data transfer in a federated CDE as standard, then in itself this will represent a huge step forward, and the benefits will be obvious in terms of better assets, less waste, higher quality and profitably.

By the time this *Handbook* is published:

- 2016 will be here
- The guidance for UK BIM Level 3 will be published in draft, and we will begin to see how we take this forward and what integrated environments are going to look like.
- We've included the Level 3 strategic document published in February 2015 – Digital Built Britain. This moves us from just BIM and the construction industry into a true vision of a digital economy in the information age.
- Arrangements for legacy post 2016, beyond the current Task Group lifetime will be settled, providing certainty for the BIM Regions, the BIM4 groups and other supporters, who are all critical to achieving Level 2 general adoption.

As you can see, there is much to be done, and I'm hoping that as we conclude this first edition of the *Construction Manager's BIM Handbook*, that you have at least found something to help and guide you on your own #BIMjourney.

With my very best wishes.

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John Eynon is a writer, blogger, architect and design manager. You can catch up with him at www.zenanddm.com

Part V
APPENDICES

Bond Bryan Architects

Appendix A

BIM Dictionary

A

Alignment is achieving complete agreement between the contents of an information model and the state of a physical asset (as defined by PAS 1192-3:2014)

Analysis is the action or process of analysing the model(s) for different purposes or a table or statement of the results of analysis of the model(s) (based on *The Chambers English Dictionary*)

Architectural Model is a model made up solely of architectural building components (as defined by Bond Bryan Architects)

Archive is a component of the common data environment (as defined by PAS 1192-2:2013)

As-built is defined as the record drawings and documentation defining deviation to the designed information occurring during construction at the end of the project (as defined by PAS 1192-2:2013)

As-constructed defines the defect and deviation to the designed model occurring during construction. The 'as-constructed' model and its appended documentation are continually updated through re-measurement as construction progresses. This allows for deviation to be reviewed with respect to the following packages and making knowledgeable assessment of impact and resolution (as defined by PAS 1192-2:2013)

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Assembly is a composition or collection of components and/or modelled elements arranged to define part or all of a building, model, structure or site. An Assembly typically contains information that can be referenced without repositioning (as defined by AEC (UK) BIM Protocol v2.0) OR a group of components or types to enable the reuse of standardised design or specification elements improving productivity of design and delivery as well as providing a location to hold specifications and lessons learnt in a simple and useable way. They may hold benchmark data for cost and carbon impacts. The contents of assemblies may themselves have attributes and classifications. These properties may include key data which is attached (to the object) for use once it is placed into a model and may include cost, CO_2, programme, maintenance and other key information (as defined by PAS 1192-2:2013) OR is a named physical aggregation of a Type or Component into another Type or Component where both the overall (owning) assembly part and the constituent (owned) part has significance for their operation and use (as defined in BS 1192-4:2014)

Asset is an item, thing of entity that has potential or actual value to an organisation (as defined by PAS 1192-3:2014) OR includes the overall Facility and the constituent aspects Space (location), Floor (region), Zone, Component, Type and System (as defined in BS 1192-4:2014)

Asset Information Management is the discipline of managing asset-related organisational data and information to a sufficient quality to support organisational objectives and outcomes (as defined by PAS 1192-3:2014)

Asset Information Model (AIM) is maintained information model used to manage, maintain and operate the asset (as defined by PAS 1192-2:2013) OR is data and information that relates to assets to a level required to support an organisation's asset management system (as defined by PAS 1192-3:2014)

Asset Information Plan is the specific information plan for the Information Model used to manage, maintain and operate the asset (as defined by the CIC Outline Scope of Services for the Role of Information Management)

Asset Information Requirements (AIR) is data and information requirements of the organisation in relation to the asset(s) it is responsible for (as defined by PAS 1192-3:2014)

Asset Management is the coordinated activity of an organisation to realise value from assets (as defined by PAS 1192-3:2014)

Asset Management System is the management system for asset management whose function is to establish the asset management policy and asset management objective (as defined by PAS 1192-3:2014)

Attribute is a piece of data forming a partial description of an object or entity (as defined by PAS 1192-2:2013) OR is a named specific characteristic associated to an asset (as defined in BS 1192-4:2014)

Author is the originator of model files, drawings or documents (as defined by PAS 1192-2:2013)

B

Bill of Quantities (BQ) means a list of items giving detail identifying descriptions and firm quantities of the work comprised in a contract (as defined by the RICS)

BIM Execution Plan – see Building Information Modelling Execution Plan

'**BIM Wash**' is a term describing the inflated – and sometimes deceptive – claim of using or delivering Building Information Modelling products or services (defined by www.thinkbimspace.com)

Building Information Management – see Information Management

Building Information Model is a digital representation of the physical and functional characteristics of the project (as defined by AIA Document E202 - 2008 - 1.2.1)

Building Information Modelling is the process of designing, constructing or operating a building or infrastructure asset using electronic object-oriented information (as defined by PAS 1192-2:2013)

Building Information Modelling Execution Plan (BEP) is a plan prepared by the suppliers to explain how the information modelling aspects of a project will be carried out (as defined by PAS 1192-2:2013)

C

Capital/Delivery Phase are major works where information is managed using PAS 1192-2:2013 and an asset is designed, procured and delivered (as defined by PAS 1192-3:2014)

CDM Coordinator is an employee whose role is to 'advise and assist the client to comply with their duties under the Construction (Design and Management) Regulations' (as defined by BS 7000-4:2013)

CIC Scope of Services are multi-disciplinary scope of services published by the Construction Industry Council (CIC) for use by members of the project team on major projects (as defined by PAS 1192-2:2013)

Clash Detection is detecting possible collisions between elements in a building information model which would not otherwise be desired or buildable on site (as defined by Bond Bryan Architects)

Clash Rendition (CR) is rendition of the native format model file to be used specifically for spatial coordination processes. To achieve clash avoidance or to be used for clash detection (as defined by PAS 1192-2:2013)

Classification is a systematic arrangement of headings and sub-headings for aspects of construction work including the nature of assets, construction elements, systems and products (as defined by PAS 1192-2:2013)

Client is the individual or organisation commissioning a built asset (as defined by PAS 1192-2:2013)

COBie (Construction Operation Building information exchange) is structured facility information for the commissioning, operation and maintenance of a project often in a neutral spreadsheet format that will be used to supply data to the employer or operator to populate decision-making tools, facilities management and asset management systems (as defined by PAS 1192-2:2013) OR is structured asset information for the commissioning, operation and maintenance of an asset often in a neutral spreadsheet format that will be used to supply data to the organisation to populate decision-making tools and asset management systems (as defined by PAS 1192-3:2014) OR subset of BS ISO 16739 IFC documented as building SMART model view definition (MVD) which includes operational information (as defined in BS 1192-4:2014)

Code is a sequence of characters, often a mnemonic, having defined meaning when interpreted in the context of the field in which it is entered, used to concisely convey meta-data (as defined by BS1192:2007-3.1)

Common Coordinates is a way of identifying the location of the model(s) or building(s) in relation to a specific agreed point. This point could be to global or local coordinates and it should be identified as to which has been used (as defined by Bond Bryan Architects/Balfour Beatty Construction)

Common Data Environment (CDE) is a single source of information for any given project, used to collect, manage and disseminate all relevant approved project documents for multi-disciplinary teams in a managed process (as defined by PAS 1192-2:2013) OR a single source of information for the project which collects, manages and disseminates relevant approved documents relating to the project (as defined by the CIC Outline Scope of Services for the Role of Information Management) OR is a single source of information for any given project or asset, used to collect, manage and disseminate all relevant approved files, documents and data for multi-disciplinary teams in a managed process (as defined by PAS 1192-3:2014)

Component is an individual building element that can be reused. Examples include doors, stair cores, furniture or internal room layouts, facade panels, etc. Components are typically inserted and moved/rotated into the required position (as defined by AEC (UK) BIM Protocol v2.0) OR a synonym for 'occurrence' (as defined by PAS 1192-2:2013) OR named and individually scheduled physical items and features that might require management, such as inspection, maintenance, servicing or replacement, during the in-use phase (as defined in BS 1192-4:2014)

Component Grade is the detail that the individual building element has been modelled to (as defined by Bond Bryan Architects)

Computer Aided Design is a geometric/symbol based computer drawing system that replicated hand-drawing techniques (as defined by the Department of Veterans Affairs, USA)

Computer-Aided Facilities Management (CAFM) is the support of Facility Management by information technology (definition taken from Wikipedia)

Concession is permission to use or release a product that does not conform to specific requirements [BS ISO 10007:2003] OR a concession against a contract requirement (gain permission for non-conformance) (as defined by PAS 1192-2:2013)

Concurrent Engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support (based on IDA definition). In a construction context it incorporates both early contractor and owner/operator involvement (as defined by PAS 1192-2:2013)

Configuration is interrelated functional and physical characteristics of a product defined in product configuration information (as defined by PAS 1192-2:2013)

Configuration Item is an entity within a configuration that satisfies an end use function (as defined by PAS 1192-2:2013)

Configuration Management is coordinated activities to direct and control configuration (as defined by PAS 1192-2:2013)

Configuration Status Accounting is formalised recording and reporting of product configuration information, the status of proposed changes and the status of the implementation of approved changes (as defined by PAS 1192-2:2013)

Connection is a named logical relationship between two Components (as defined in BS 1192-4:2014)

Constant in constraints, a fixed value, such as a length or specific name (as defined by Digital Building Lab @ Georgia Tech, USA)

Constraint a mathematical expression, often algebraic, defining equalities (=) or inequalities (<,>) across various parameters. Constraint may be geometrical, such as parallelism, or a specified angle relation (as defined by Digital Building Lab @ Georgia Tech, USA)

Consultant Model mean a model that utilises data imported from a design model or, if none, from a designer's construction documents; and contains the equivalent of shop drawings and other information useful to construction (as defined by ConsensusDOCS 301 BIM Addendum, US)

Construction Agent is a human participant in a construction process (as defined by ISO 12006-2:2001 - 2.19)

Construction Aid material construction resource not intended for incorporation in a permanent manner in a building or other construction entity (as defined by ISO 12006-2:2001 - 2.18)

Construction Complex are two or more adjacent construction entities collectively serving one or more user activity or function (as defined by ISO 12006-2:2001 - 2.5)

Construction Entity independent material construction result of significant scale serving at least one user activity or function (as defined by ISO 12006-2:2001 - 2.4)

Construction Entity Part is a solid (as distinct from liquid and gaseous), material part of a construction entity, having physically delineated boundaries (as defined by ISO 12006-2:2001 - 2.6)

Construction Information is information used to support one or more construction processes (as defined by ISO 12006-2:2001 - 2.20)

Construction Model is a model created to show how the building will be built in sequence. This type of model will often include cranes, scaffolding and other elements required to construct the final building (as defined by Bond Bryan Architects)

Construction Product material construction resource intended for incorporation in a permanent manner in a building or another construction entity (as defined by ISO 12006-2:2001 - 2.17)

Construction Process is the process which transforms construction resources into construction results (as defined by ISO 12006-2:2001 - 2.11)

Construction Result is a construction object which is formed or changed in state as the result of one or more construction processes utilising one or more construction resources (as defined by ISO 12006-2:2001 - 2.3)

Construction Sequencing is the process of adding a time line to a model. This can be incorporated into both design or construction models (as defined by Balfour Beatty Construction)

Contact is a named person and/or organisation involved in the Facility lifecycle (as defined in BS 1192-4:2014)

Container is a named persistent set of data within a file system or application data storage hierarchy including, but not limited to, directory, sub-directory, data file, or distinct sub-set of a data file, such as a chapter or section, layers or symbol (as defined by BS1192:2007- 3.2)

Container Model is an optional repository which can be used to compile assemblies and components for specific purposes including export and publication. A Container can exist for each individual profession/discipline or for multiple disciplines, for buildings or for a complete project (as defined by AEC (UK) BIM Protocol v2.0)

Contribution means the expression, design, data or information that a project participant creates or prepares and incorporates, distributes, transmits, communicates or otherwise shares with other project participant(s) for use in or in connection with a model for the project (based on definition by ConsensusDOCS 301 BIM Addendum, US)

Convention is an accepted way of drawing an item which may have the nature of a representation, a simplified representation or a symbol (as defined in BS 8541-2:2011)

Conventionial Cartesian Axis Geometric convention using positive coordinates (X,Y,Z) ordered as (East, North, upwards), so that conventional plans use X,Y and Z is upwards (as defined by BS1192:2007- 3.3)

Coordinate means combining or integrating harmoniously different elements within the model (based on The Chambers English Dictionary) OR is a named position associated to Facility, Floor (region), Space (location), Component or Assembly (as defined in BS 1192-4:2014)

D

Data is information stored but not yet interpreted or analysed (as defined by PAS 1192-2:2013) OR observations that in context yields information (as defined by PAS 1192-3:2014/Skyrme & Amidon, Knowledge management, Institute of Management, Corby, 1997)

Data Capture means putting information into a form that can be fed directly into a computer (based on *The Chambers English Dictionary*)

Data manager is the organisational representative responsible for establishing governance and assuring data and information flow to and from the AIM (as defined by PAS 1192-3:2014)

Data Store is a repository for data within the AIM (as defined by PAS 1192-3:2014)

Deficiency detection is detecting possible omissions within the model which would be required to construct the project on site (as defined by Bond Bryan Architects)

Deliverables are the specific requirements for the project which may be generated directly from the model or from other sources. They may include the building information model, drawings, fly-throughs, images, data, schedules or reports (as defined by Bond Bryan Architects)

Designed Element is an element for which the work section(s) have been defined (as defined by ISO 12006-2:2001 - 2.9)

Design Lead is the role of setting design standards and coordinating the design (as defined by the CIC Outline Scope of Services for the Role of Information Management)

Design Model means a model of those aspects of the project that have reached the stage of completion that would customarily be expressed by an Architect/Engineer in two-dimensional construction documents. This shall not include models such as analytical evaluations, preliminary designs, studies, or renderings. A model prepared by an Architect/Engineer that has not reached the stage of completion specified is referred to as a model (as defined by ConsensusDOCS 301 BIM Addendum, US)

Design Intent Model is the initial version of the project information model (PIM) developed by the design suppliers (as defined by PAS 1192-2:2013)

Design Team means the architect(s), engineer(s) and technology specialists responsible for the conceptual design aspects of a building, structure or facility and their development into models, drawings, specifications and instructions required for construction and associated processes. The design team is part of the project team (bases on the definition by the RICS)

digital Plan of Work (dPoW) is a generic schedule of phases, roles, responsibilities, assets and attributes, made available in a computable form (as defined in BS 1192-4:2014)

Dimensional Control is a risk mitigation process that applied to a project execution task that requires a dimensional accuracy (based on definition in 'Common Scan and Building Information Modelling Terms' by Severn Partnership)

Dispositioning Authority is a person or a group of persons assigned responsibility and authority to make decisions on the configuration (as defined by PAS 1192-2:2013)

Document is a container for persistent information that can be managed and interchanged as a unit (as defined by BS1192:2007 - 3.4) OR information for the use in the briefing, design, construction, operation, maintenance or decommissioning of a construction project, including but not limited to correspondence, drawings, schedules, specifications, calculations, spreadsheets (as defined by PAS 1192-2:2013) OR is a named external document associated to an asset (as defined in BS 1192-4:2014)

Document Repository is an entity including an electronic data management (EDM) system, project extranet or folder hierarchy on a Windows file server (as defined by PAS 1192-2:2013)

Drawing is a document used to present graphic information (as defined by BS1192:2007 - 3.5) OR static, printed, graphical representation of part or all of a project or asset (as defined by PAS 1192-2:2013)

Drawing Title Block is a framework – often containing the project team's logos – to show the drawing title, number, purpose of issue, status and revision information (as defined by PAS 1192-2:2013)

E

Earned Value Analysis (EVA) is a method of project performance measurement that integrates cost, time and scope (as defined by PAS 1192-2:2013)

Electronic Document Management System (EDMS) is a system for storing, retrieving, sharing and otherwise managing electronic documents (as defined by PAS 1192-2:2013)

Employer is the individual or organisation named in an appointment or building contract as the employer (as defined by PAS 1192-2:2013 and PAS 1192-3:2014) or means the person appointing the Project Team Member pursuant to the agreement and any valid assignee of the Employer's rights and obligations under this Protocol subject to the terms of such assignment. (CIC BIM Protocol. First Edition. 2013)

Employer's Information Requirements (EIR) is a document setting out the information to be delivered, and the standards and processes to be adopted by the supplier as part of the project delivery process (as defined by PAS 1192-2:2013) OR pre-tender document setting out the information to be delivered, and the standards

and processes to be adopted by the supplier as part of the project delivery process (as defined in BS 1192-4:2014)

Element is a construction entity part which, in itself or in combination with other such parts, fulfils a predominating function of the construction entity (as defined by ISO 12006-2:2001 - 2.7)

Elevations Orthographic views taken directly from the model (as defined by Bond Bryan Architects)

Employer means the owner and/or developer of the building; in some cases the ultimate user. The terms Senior Responsibility Owner (SRO) and project sponsor are used for central civil government and defence sector; being the representatives empowered to manage the building project and make project-specific decisions (as defined by the RICS)

Energy Analysis is the action or process of analysing the model(s) from an energy point of view or a table or statement of the results of analysis of the model(s) (based on The Chambers English Dictionary)

Entity is a synonym for 'object' (as defined by PAS 1192-2:2013)

F

Facility is the named operational built or geographical asset, typically a building or section of infrastructure along with details and extent of the geographic site and of the temporal project (as defined in BS 1192-4:2014)

Facility Management is management during the operational phase of a facility or building's lifecycle, which normally extends over many decades. It represents a continuous process of service provision to support the client's core business and one where improvement is sought on a continuous basis (definition taken from Wikipedia)

Fabrication Model is a Building Information Model which incorporates components that are suitable for fabrication. It is a development of the Full Design Model to include more detail (as defined by Bond Bryan Architects)

Federated Model means a model consisting of linked but distinct component models, drawings derived from the models, texts and other data sources that do not lose their identity or integrity by being so linked, so that a change to one component model in a federated model does not create a change in another component model in that federated model (as defined by ConsensusDOCS 301 BIM Addendum, US) OR is a model consisting of connected but distinct individual models (CIC BIM Protocol. First Edition. 2013)

Field Part of a container name reserved for meta-data (as defined by BS1192:2007-3.6)

File Extension is an added piece of information to the end of a file name to explain the format of the file. This is often in the form of .abc. Typically file extensions are 3 or 4 characters long (as defined by Bond Bryan Architects)

File Store is the repository for information within the asset information model (as defined by PAS 1192-3:2014)

Floor (region) is the named intermediate spatial subdivision, including distinct vertical levels and horizontal areas and sections with Spaces allocated (as defined in BS 1192-4:2014)

Full Design Model means a model consisting of coordinated structural, architectural, MEP and other design models (based on definition by ConsensusDOCS 301 BIM Addendum, US)

G

Gate is a division of a standardised process map for the acquisition of a facility, at some of which the requirement can be delivered (as defined by PAS 1192-2:2013)

Generic Object is a type object intended for use in stages of design when the object is not resolved into a product (as defined in BS 8541-1:2012, BS 8541-3:2012 and BS 8541-4:2012)

Ground Penetrative Radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. It can detect objects, changes in material, and voids and cracks (definition taken from Wikipedia)

Graphical Data is data conveyed using shape and arrangement in space (as defined by PAS 1192-2:2013)

Graphical File is a file format designed specifically for representing graphical images (as defined by PAS 1192-2:2013)

H

Handover is the stage of a capital/delivery project where the asset is made available for use or occupation (as defined by PAS 1192-3:2014)

I

Impact is a named economic and environment measure (as defined in BS 1192-4:2014)

Industry Foundation Classes (IFC) is a neutral and open specification that is not controlled by a single vendor or group of vendors. It is an object-based file format with a data model developed by buildingSMART to facilitate interoperability in the building industry (as defined by Nemetschek – source taken from Wikipedia) OR is a neutral and

open specification, object-based file format with a data model developed by building SMART to facilitate interoperability in the architecture, engineering and construction (AEC) industry (as defined by BS 7000-4:2013)

Information is the representation of data in a formal manner suitable for communication, interpretation or processing by human beings or computer applications (as defined by PAS 1192-2:2013) OR data arranged and processed into meaningful patterns, put into context (as defined by PAS 1192-3:2014/Skyrme & Amidon, Knowledge management, Institute of Management, Corby, 1997)

Information Device is a convention indicating an abstract item (as defined in BS 8541-2:2011)

Information Exchange is the structured collection of information at one of a number of pre-defined stages of a project with defined format and fidelity (as defined by PAS 1192-2:2013)

Information Management means measures that protect and defend information and information systems with respect to their availability, integrity, authentication, confidentiality and non-repudiation. These measures include providing for restoration of information systems by incorporating protection, detection, and reaction capabilities (as defined by ConsensusDOCS 301 BIM Addendum, US) OR are tasks and procedures applied to inputting, processing and generation activities to ensure accuracy and integrity of information (as defined by PAS 1192-2:2013)

Information Management Process (IMP) is the process to manage information related to the operational phase of an asset (as defined by PAS 1192-3:2014)

Information Management Role means a role in connection with the project which includes, inter alia, the establishment and management of the processes, protocols and procedures set out in the Information Requirements. (CIC BIM Protocol. First Edition. 2013)

Information Manager means one or more individuals responsible for the BIM's Information Management program (based on definition by ConsensusDOCS 301 BIM Addendum, US) OR means the person appointed, initially by the Employer, to perform the Information Management Role. (CIC BIM Protocol. First Edition. 2013)

Information Model is a model comprising: documentation, non-graphical information and graphical information (as defined by PAS 1192-2:2013) OR is all documentation, non-graphical information which the Project Team is required to provide into the Information Model by the Scope of Services for the Project Team and which is provided for the purpose of delivering Project Outputs (as defined by the CIC Outline Scope of Services for the Role of Information Management)

Information Modelling is the use of data to provide information through better understanding, by applying logic or mathematical functions to derive new data (as defined by PAS 1192-2:2013)

Information Requirements means the document *attached to this Protocol at Appendix 2* setting out the way in which Models shall be produced, delivered and

used on the Project, including any processes, protocols and procedures referred to therein. (CIC BIM Protocol. First Edition. 2013)

Instance is an occurrence of an entity at a particular location and orientation within a model (as defined by BS1192:2007 - 3.7)

Interoperability is the ability of two or more systems or components to exchange information and to the use the information that has been exchanged (as defined by IEEE on Wikipedia)

International Framework for Dictionaries (IFD) is the standard terminology for libraries or ontologies (as defined by BS 7000-4:2013) *Note: this is now called buildingSMART Data Dictionary (bsDD)*

Integrated Project Delivery (IPD) is a collaborative alliance of people, systems, business structures and practices into a process that harnesses the talents and insights of all participants to optimise project results, increase value to the owner, reduce waste, and maximise efficiency through all phases of design, fabrication and construction (as defined by AIA - source taken from Wikipedia)

Issue is a named deficiency in the information or risk associated to an asset (as defined in BS 1192-4:2014)

J

Job is the named task or activity during the in-use phase associated to Types (as defined in BS 1192-4:2014)

L

Laser Scanning is controlled steering of laser beams followed by a distance measurement at every pointing direction used to rapidly capture shapes of objects, structures, buildings and landscapes (based on definition taken from Wikipedia). Layer is a container comprising selected entities, typically used to group for purposes of selective display, printing and management operations (as defined by BS1192:2007 - 3.8)

Layer is an attribute given to entities with CAD files enabling their visibility to be controlled. Further values may be assigned to the attribute to enable control whether it can be edited or deleted (as defined by PAS 1192-2:2013)

Lean is production focused on delivering value for the employer or client and eliminating all non-value-adding activities using an efficient workflow (as defined by PAS 1192-2:2013)

Lean Principles is understanding value from a client's perspective, identifying the value stream, establish a balanced flow of work, in which the demand for product is pulled from the next customer, with a constant drive for continuous improvement and perfection (Based on *Lean Thinking*, Womack & Jones, 2003 edition) (as defined by PAS 1192-2:2013)

Level of Attributing is categorisation based on a minimum content of attributing information on a library object (as defined by BS 8541-3:2012)

Levels of Definition is the collective term used for and including 'level of model detail' and the 'level of information detail' (as defined by PAS 1192-2:2013)

Level of Detail means the level of detail required for a Model *as specified in Appendix I attached to this Protocol*. (CIC BIM Protocol. First Edition. 2013) OR completeness and accuracy of a virtual shape representation compared to the physical and functional characteristics of the actual object (as defined in BS 8541-3:2012) *See also Levels of Model Detail*

Level of Development (LOD) describes the level of completeness to which a Model Element is developed (as defined by AIA Document E202 - 2008 - 1.2.2). *Note: This does not apply to UK projects - see Level of Definition.*

Level of Information (LOI) – See Levels of Model Information

Level of Measurement is the completeness and accuracy of a virtual measurement compared to the physical and functional characteristics of the actual object (as defined by BS 8541-3:2012)

Levels of Model Detail is a description of graphical content of models at each of the stages defined for example in the CIC Scope of Services (as defined by PAS 1192-2:2013)

Levels of Model Information is a description of non-graphical content of models at each of the stages defined for example in the CIC Scope of Services (as defined by PAS 1192-2:2013)

'**Lonely BIM**' is a non-collaborative 3D model produced by a single designer (phrase coined by Robert Klaschka of Studio Klaschka; definition by Bond Bryan Architects)

Lifecycle Assessment is the methodology used to establish a Lifecycle Costing for a material or a product (as defined by Willmott Dixon)

M

Main Contractor (or Prime Contractor) means the contractor responsible for the total construction and completion process of the building project. The term prime contractor is often used in central civil government and the defence sector to mean main contractor (as defined by the RICS)

Maintainer is the individual, department or organisation engaged by either the owner or operator of an asset to carry out maintenance on or in connection with that asset (as defined by PAS 1192-3:2014)

Maintenance is the combination of all technical and associated administrative actions to retain or restore an asset to a state in which it can perform its required function (as defined by PAS 1192-3:2014/adapted from BS ISO 15686-1:2011, BS ISO 6707-1:2004)

Major works are works within the scope of PAS 1192-2:2013 (as defined by PAS 1192-3:2014)

Manageable Assets are those aspects of the facility that may be managed during the facility lifecycle include both physical and spatial objects, and their functional groupings (as defined by PAS 1192-2:2013)

Management of assets are operational activities carried out on assets in support of those assets meeting their requirements (as defined by PAS 1192-3:2014)

Marked-up Drawing is a paper or electronic drawing that has been marked up with comments from other disciplines or the client (as defined by PAS 1192-2:2013)

Master Information Document Index (MIDI) is the index specifying a detailed list of deliverables for a project; for model, sub-models, documents and data also allocating responsibility to deliver and the programme for delivery of a project supply chain (as defined by PAS 1192-2:2013)

Master Information Delivery Plan (MIDP) is the primary plan for when project information is to be prepared, by whom and using what protocols and procedures, incorporating all relevant task information delivery plans (as defined by PAS 1192-2:2013)

Material means all information in any electronic medium prepared by or on behalf of the Project Team Member comprised in: (a) the Specified Models; and (b) the Federated Models, to the extent that these comprise Specified Models or to the extent that the Project Team Member owns any additional rights in any Federated Model, excluding any material forming part thereof which is provided to the Project Team Member by or on behalf of the Employer. (CIC BIM Protocol. First Edition. 2013)

MEP Model is a model made up solely of mechanical, electrical and plumbing components (note: other information may exist within this model that is referenced from others but this is only used for reference purposes) (as defined by Bond Bryan Architects)

Meta-data is data used for the description and management of documents and other containers of information (as defined by BS1192:2007 - 3.9)

Metrics acceptability of the deliverable may be assessed against the requirements shown in the examples and/or against indicative ratios and counts based on the information provided (as defined by PAS 1192-2:2013)

Minor Works are works carried out on an asset where information is managed using PAS (as defined by PAS 1192-3:2014)

Model is a collection of containers organised to represent the physical parts of objects, for example a building or a mechanical device (as defined by BS1192:2007 - 3.10) OR a three-dimensional representation in electronic format of building elements representing solid objects with true-to-scale spatial relationships and dimensions. A model may include additional information or data (as defined by ConsensusDOCS 301 BIM Addendum, US) OR means a digital representation of part of the physical and/or functional characteristics of the Project. (CIC BIM Protocol. First Edition. 2013)

Model Element is a portion of the Building Information Model representing a component, system or assembly within a building or building site (as defined by AIA Document E202 - 2008 - 1.2.3)

Model Element Author (MEA) is the party responsible for developing the content of a specific Model Element to the Level of Development (LOD) required for a particular phase of the project (as defined by AIA Document E202 - 2008 - 1.2.4)

Model File is a native, proprietary format, CAD file that can be a 2D or 3D model (as defined by PAS 1192-2:2013)

Model Production and Delivery Table means the table *attached to this Protocol at Appendix I* specifying the subject matter of each Model, the person who is to produce and deliver each Model (described in the table as 'Model Originator') at each Stage and the Level of Detail for each Model at each Stage. (CIC BIM Protocol. First Edition. 2013)

Model User refers to any individual or entity authorised to the use the model on the project, such as for analysis, estimating or scheduling (as defined by AIA Document E202 - 2008 - 1.2.5)

N

Non-graphical Data is data conveyed using alphanumeric characters (as defined by PAS 1192-2:2013)

O

Object is any part of the perceivable or conceivable world (as defined by ISO 12006-2:2001 - 2.1) OR an item having state, behaviour and unique identity – for example, a wall object (as defined by PAS 1192-2:2013)

Occurrence Object is a representation of an actual occurrence (instance) of an object in a building (as defined in BS 8541-1:2012, BS 8541-3:2012 and BS 8541-4:2012)

OGC Gateway Process is a process that examines programmes and projects at key decision-points in their lifecycle. It looks ahead to provide assurance that the employer can progress to the next stage (as defined by the RICS (partial))

OGC Gateway(s) are the key decision points within the OGC Gateway Process (as defined by the RICS)

Open BIM is a unique approach to collaborative design and realisation of buildings allowing project members to participate regardless of the tools they use (as defined by Graphisoft)

Operational Information is information specifying operational activity associated to Types (as defined in BS 1192-4:2014)

Operator is an organisation that uses an asset to create value but does not own the asset (as defined by PAS 1192-3:2014)

Organisation is a person or group of people that has its own functions with responsibilities, authorities and relationships to achieve its objectives (as defined by PAS 1192-3:2014/ISO/FDIS 55000:2013)

Organisational Information Requirements is data and information required to achieve the organisation's objectives (as defined by PAS 1192-3:2014)

Origin is a setting out point for a project or programme using coordinate geometry or related to the OS or geospatial reference (as defined by PAS 1192-2:2013)

Originator is the agent responsible for production of a container (as defined by BS1192:2007 - 3.11) OR is the author of models, drawings and documents (as defined by PAS 1192-2:2013)

Other Project Team Member means any person having responsibilities in relation to the production, delivery and/or use of Models and appointed by the Employer in relation to the Project, excluding the Project Team Member. (CIC BIM Protocol. First Edition. 2013)

Output File (see also Views) is a generated rendition of graphical or non-graphical information (a plan, section, elevation, schedule, table or other view of a project) (as defined by AEC (UK) BIM Standard Version 1 Page 7)

Owner is an organisation that owns an asset and uses the asset either directly or indirectly to create value (as defined by PAS 1192-3:2014)

P

Parameters are variables used in a function or equation to assign values: coordinate, dimension, material, distance, angle, colour, unit price, energy coefficient, and so forth (as defined by Digital Building Lab @ Georgia Tech, USA)

Permitted Purpose means a purpose related to the Project (or the construction, operation and maintenance of the Project) which is consistent with the applicable, Level of Detail of the relevant Model (including a Model forming part of a Federated Model) and the purpose for which the relevant Model was prepared. (CIC BIM Protocol. First Edition. 2013)

Placeholder is simplified or generic representation of a 3D object (as defined by PAS 1192-2:2013)

Plain Language Questions are questions asked of the supply chain by the employer to inform decision-making at key stages of an asset lifecycle or project (as defined by PAS 1192-3:2014)

Point Cloud is a set of vertices in a three-dimensional coordinate system. These vertices are usually defined by X, Y and Z coordinates, and typically are intended to be representative of the external surface of an object. Point clouds are most often

created by 3D scanners. These devices measure in an automatic way a large number of points on the surface of an object, and often output a point cloud as a data file. The point cloud represents the set of points that the device has measured (as defined on Wikipedia)

Product Object is a type object intended to represent an obtainable product, either as a requirement or exemplar or as-built (as defined in BS 8541-1:2012, BS 8541-3:2012 and BS 8541-4:2012)

Project Delivery Team are a group of organisations or individuals contracted either directly or indirectly to deliver services or products to the project (as defined by PAS 1192-2:2013)

Point Density is the number of points per unit. Usually the higher the point density is, the better representation of features are (as defined in 'Common Scan and Building Information Modelling Terms' by Severn Partnership)

Project BIM Protocol is the Project Specific BIM Protocol setting out the obligations of the principal members of the Project Team in respect of the use of BIM on the Project (as defined by the CIC Outline Scope of Services for the Role of Information Management)

Project Delivery Team are groups of organisations or individuals contracted either directly or indirectly to deliver services or products to the project (as defined by PAS 1192-2:2013)

Project Information Model (PIM) is the information model developed during the design and construction phase of a project, consisting of documentation, non-graphical information and graphical information defining the delivered project (as defined by PAS 1192-2:2013) OR is the information model developed during the design and construction phase of a project [PAS 1192-2:2013] (as defined by PAS 1192-3:2014)

Project Information Plan is the plan for the structure and management and exchange of information from the Project Team in the Information Model and the related processes and procedures (as defined by the CIC Outline Scope of Services for the Role of Information Management)

Project Implementation Plan (PIP) is a statement relating to the suppliers' IT and human resources capability to deliver the EIR (as defined by PAS 1192-2:2013)

Project Outputs is configured information delivered from the Information Model for a specific Permitted Purpose, e.g. Stage Outputs, Employer information exchanges, submissions for planning, procurement, construction (as defined by the CIC Outline Scope of Services for the Role of Information Management)

Project Stage is a period of time in the duration of a construction project identified by the overall character of the construction process which occurs within it (as defined by ISO 12006-2:2001 - 2.15)

Project Team is compromised of the Project Team Members (as defined by the CIC Outline Scope of Services for the Role of Information Management)

Project Team Member means the person appointed by the Employer *pursuant to the Agreement*. (CIC BIM Protocol. First Edition. 2013) OR any person having responsibilities in relation to the production, delivery and/or use of the content of the Information Model and appointed by the Employer in relation to the Project (as defined by the CIC Outline Scope of Services for the Role of Information Management)

Project Team Models means any Models which Other Project Team Members produce and deliver as specified in the Model Production and Delivery Table and any Federated Models (or any part thereof) produced and delivered by Other Project Team Members. (CIC BIM Protocol. First Edition. 2013)

Published published information refers to documents and other data from Shared information. Typically this will include exported data, contract drawings, reports and specifications (reference BS1192:2007) (as defined by AEC (UK) BIM Protocol v2.0) OR a component of the CDE for drawing renditions that have been approved as suitable for a specific purpose – for example, suitable for construction (as defined by PAS 1192-2:2013)

Purpose of Issue states the purpose for issuing the document (as defined by PAS 1192-2:2013)

Purposes are those aspects of the Facility that are intended to be managed by the facility owner (as defined by PAS 1192-2:2013)

R

RACI indicator is an abbreviation used to identify which of a group of participants or stakeholders are responsible for ('R'), authorise ('A'), contribute to ('C') or are kept informed about ('I') a project activity (as defined by PAS 1192-2:2013)

RAG report is a performance report summarising a series of assessments as red (does not meet requirement), amber (does not meet requirement but plan in place to bring up to standard), or green (meets requirements) (as defined by PAS 1192-3:2014)

Record Model The final version of the digital model used by the construction team to construct the building (as defined by Bond Bryan Architects)

Reference file is a CAD model file associated or linked with another CAD model file. Also referred to as an 'X-ref' (as defined by PAS 1192-2:2013)

RIBA Outline Plan of Work summarises the deliverables required under each RIBA Work Stage (as defined by the RICS)

RIBA Work Stage means the stage into which the process of designing building projects and administering building contracts may be divided (as defined by the RICS)

Rendition is documentation in a form enabling the information to be viewed, printed and marked up. For example, PDF and DWF files are documentation consisting of snapshots (as defined by PAS 1192-2:2013)

Requirements are the documented expectations of facility owners/commissioners for sharable structured information. These are also referred to as the Employers Information Requirements (EIR) (alternatively, the Clients Information Requirements) (as defined by PAS 1192-2:2013)

Representation is the scale view of an object (as defined in BS 8541-2:2011)

Resource is named material or skill required to execute Jobs (as defined in BS 1192-4:2014)

Revision is used to identify revisions of documents, drawing and model files (as defined by PAS 1192-2:2013)

S

Shared information that has been checked and approved and is made available across the project team such as information for data exchange between BIM software, like gbXML, CIS/2 and IFC files (reference BS1192:2007) (as defined by AEC (UK) BIM Protocol v2.0) OR component of the CDE. The shared section of the CDE is where information can be made available to others in a 'safe' environment. The early release of information assists in the rapid development of the design solution. To allow this to be achieved, the concept of information 'status/suitability' has been adopted (as defined by PAS 1192-2:2013)

Simplified Representation is a scale view incorporating only the essential shape, size or features of an object (as defined in BS 8541-2:2011)

Soft Landings are graduated handover of a built asset from the design and construction team to allow structured familiarisation of systems and components and fine tuning of controls and other building management systems (as defined by PAS 1192-2:2013)

Space three-dimensional, material construction result contained within, or otherwise associated with, a building or other construction entity (as defined by ISO 12006-2:2001 - 2.10) OR named location for activities such as use, inspection or maintenance, including un-occupied or un-inhabitable Spaces, but not necessarily inaccessible voids (as defined in BS 1192-4:2014)

Spare is a named replaceable part associated to Types (as defined in BS 1192-4:2014)

Specification is identification of the requirements on objects including the subsequent selection of products during installation and replacement (as defined by BS 8541-4:2012)

Specified Models means the Model or Models which the Project Team Member is to produce and deliver as specified in the Model Production and Delivery Table. (CIC BIM Protocol. First Edition. 2013)

Stage – see Gate

Standard Font is the agreed set of font types and sizes used for the project (as defined by PAS 1192-2:2013)

Standard Layering Convention is the single layering convention used by the project team (as defined by PAS 1192-2:2013)

Standard Method and Procedure are a set of standard methods and procedures covering the way information is named, expressed and referenced (as defined by PAS 1192-2:2013)

Status defines the 'suitability' of information in a model, drawing or document. Not to be confused with the status in architectural documentation as 'new build', 'retain' or 'demolish' (as defined by PAS 1192-2:2013)

Structural Analysis is the action or process of analysing the model(s) from a structural point of view or a table or statement of the results of analysis of the model(s) (based on *The Chambers English Dictionary*)

Structural Model A model made up solely of structural components (as defined by Bond Bryan Architects)

Subcontractor means a contractor employed by the main contractor to undertake specific work within the building project; also known as specialist, works, trade, work package, and labour only contractors (as defined by the RICS)

Sub-model Model included as an instance in another model (as defined by BS1192:2007 - 3.12)

Supervisory control and data acquisition (SCADA) are systems that collect operational data from assets to support supervisory and other managerial activities (as defined by PAS 1192-3:2014)

Supplementary Information is additional descriptive information associated to the assets (as defined in BS 1192-4:2014)

Supplier is the provider of services or goods either directly to the employer or to another supplier in a supply chain (as defined by PAS 1192-2:2013)

Supplier Information Modelling Assessment Form is a form conveying the capability and experience of a supplier to carry out information modelling in a collaborative environment (as defined by PAS 1192-2:2013)

Supplier Information Technology Assessment Form is a form conveying the capability and IT resources of a supplier for exchanging information in a collaborative environment (as defined by PAS 1192-2:2013)

Supply Chain Capability Assessment Form is a form summarising the human resource and IT capability of each organisation in a supply chain (as defined by PAS 1192-2:2013)

Symbol is a graphic device without scale used: a) on a drawing to indicate the occurrence and/or location of an item; b) in annotation to indicate one or more of the attributes of an item (as defined in BS 8541-2:2011)

Symbol Element (Element) is a graphic device without scale used only in combination with a symbol (or symbols) or with other elements, to form a symbol (as defined in BS 8541-2:2011)

System is a group of components that work together to provide a specific building service such as envelope, ventilation or fire protection (as defined by PAS 1192-2:2013) OR named set of manageable Components providing a common function (as defined in BS 1192-4:2014)

System (IFC) are an organised combination of related parts, composed for a common purpose or function or to provide a service. System is essentially a functionally related aggregation of products (as defined by PAS 1192-2:2013)

Systems Engineering is an interdisciplinary approach enabling the realisation of successful systems (as defined by PAS 1192-2:2013)

T

Task Information Delivery Plan (TIDP) is federated lists of information deliverables by each task, including format, date and responsibilities (as defined by PAS 1192-2:2013)

Template Object is a type object intended to guide the production of generic objects and product objects by providing schedules of classification values and a minimum set of attributes (as defined in BS 8541-1:2012, BS 8541-3:2012 and BS 8541-4:2012)

Third Party Capability Assessment Form is a form conveying the information management and IT capabilities of non-design, non-construction organisations in a supply chain (as defined by PAS 1192-2:2013)

Trigger is a planned or unplanned event that changes and asset or its status (as defined by PAS 1192-3:2014)

Trigger-related Event is a response to a trigger and the reflection of the altered state of the asset in the AIM (as defined by PAS 1192-3:2014)

Type is a named specification for Components providing a common function (as defined in BS 1192-4:2014)

Type (Library) Object is a representation of the common features of a product or group, including its classifications and properties (as defined in BS 8541-1:2012, BS 8541-3:2012 and BS 8541-4:2012)

U

Uniclass (Unified Classification for the Construction Industry) Published by the Construction Project Information Committee (CPIC) this is a UK standard for classification

User is an individual using a built asset for its designed purpose (as defined by PAS 1192-2:2013)

V

Version is sub-indexing to revision as used in the common data environment to show the development of information and information models, e.g. if a version is named P1.1, P1 is the revision number and the .1 is the version to that revision (as defined by PAS 1192-2:2013)

Views (see also Output files) is a generated rendition of graphical or non-graphical information (a plan, section, elevation, schedule, or other view of a project (as defined by AEC (UK) BIM Protocol v2.0)

Virtual Construction Model is the subsequent version of the project information model developed from design intent model by the construction supplier and their supply chain (as defined by PAS 1192-2:2013)

Volume is manageable spatial subdivision of a project, defined by the project team as a subdivision of the overall project that allows more than one person to work on the project models simultaneously and consistent with analysis and design process (as defined by PAS 1192-2:2013). *Note: this term is defined as 'zone' in BS 1192:2007*

W

Work In Progress (WIP) is each individual company or discipline's own work. This is information that has not been approved or verified as fit to share across the project team (reference BS1192:2007) (as defined by AEC (UK) BIM Protocol v2.0)

X

X-ref is a CAD model file associated or linked with another CAD model file. Also referred to as a 'reference file' (as defined by PAS 1192-2:2013)

Z

Zone is a named set of Spaces (locations) sharing a specific Attribute, such as activity, access, management or conditioning (as defined in BS 1192-4:2014)

Bond Bryan Architects

Appendix B

BIM Acronyms

No.	
2D	2-dimensional
3D	3-dimensional
4D	Time
5D	Cost
6D	Lifecycle and Facilities Management
A	
Ac	Activities table (CPIC Uniclass 2)
AD4	Asset Data Dictionary Definition Document (Crossrail Limited)
ADM	Activity Definition Model
ADMM	Asset Data Management Manual (Highways Agency)
ADQ	Actual Digital Questions
AEC	Architectural, Engineering and Construction
AIA	American Institute of Architects (US)
AIM	Asset Information Model/Modelling
AIMS	Asset Information Management System (Crossrail Limited)
AIR	Asset Information Requirements
AM	Asset Management
AMO	Asset Management Office (Highways Agency)
AMP	Agreed Maximum Price
API	Application Programming Interface
APM	Association for Project Management
ASP	Application Service Provider
Avanti	(UK Government sponsored to assist collaboration)

Construction Manager's BIM Handbook, First Edition. John Eynon.

No.	
B	
B&ES	Building and Engineering Services Association (formerly known as HVCA)
BAS	Building Automation System
BCF	BIM collaboration format
BEP	BIM Execution Plan
BES	Building Energy Simulation
BIM	Building Information Model/Modelling/Management
BIM(M)	Building Information Modelling and Management
BIS	UK Department for Business, Innovation and Skills
BLPU	Basic Land and Property Unit
BMS	Building Management System
BOOT	Build-own-operate-transfer
BQ	Bill of quantities
BQBS	Bill of quantities (or BQ) breakdown structure
BRE	Building Research Establishment
BREEAM	Building Research Establishment's Environmental Assessment
BrIM	Bridge Information Model
BS	British Standard
bSa	buildingSMART alliance
bsDD	buildingSMART Data Dictionary
bSI	buildingSMART International
BSI	British Standards Institute
BSIM	Building Services Information Model
BSRIA	Building Services Research and Information Association
C	
CA	Contract Administrator
CAD	Computer Aided Design
CADD	Computer Aided Design and Drafting
CAFM	Computer Aided Facility Management
CAM	Computer Aided Manufacture
CAPEX	Capital Expenditure
CATIA	Computer Aided Three-dimensional Interactive Application
CAWS	Common Arrangement of Work Sections
CBS	Cost Breakdown Structure
CD	Compact Disc
CDE	Common Data Environment
CDF	Common Data Format
CDM	Construction (Design and Management) Regulations
CDPA	Copyright, Designs and Patent Act

No.	
CE	Constructing Excellence
CEN	European Committee for Standardisation
CERL	Construction Engineering Research Laboratory (USACE)
CFD	Computational Fluid Dynamics
C/I	Civils/Infrastructure
CIAT	Chartered Institute of Architectural Technologists
CIBSE	Chartered Institution of Building Services Engineers
CIC	Construction Industry Council
CIS	Construction Information Service
CITE	Construction Industry Trading Electronically
CMM	Capacity Maturity Model or Coordinate Measurement Machine
CMMS	Computerised Maintenance and Management System
CNC	Computer Numerical Control
Co	Complexes table (CPIC Uniclass 2)
COBie	Construction Operations Building Information Exchange
CoP	Code of Practice
CPI	Co-ordinated Project Information
CPIC	Construction Project Information Committee
CPIx	Construction Project Information Xchange
CPMS	Capital Planning and Management System
CPR	Construction Progress Reporting
CR	Clash Rendition
CRC	Carbon reduction commitment
CRL	Crossrail Limited
CRS	Coordinate Reference System
CRV	Capitalised replacement value
CSG	Constructive Solid Geometry
CSI	Construction Specifications Institute
D	
D&B	Design and Build
DBFO	Design, Build, Finance, Operate
DBMS	Data Base Management System
DCF	Discounted cash flow
DCLG	Department for Communities and Local Government
DDS	Data Design System
DFMA	Design for Manufacturer and Assembly
DfT	Department for Transport

(*continued overleaf*)

No.			
DMS	Document Management System		
DPP	Developed Constructor Proposals	DRC	Depreciated reinstatement cost

E

EAM	Enterprise Asset Management
EC	European Committee
ECI	European Construction Institute or Early Contractor Involvement
EDI	Electronic Data Interchange
EDM	Electronic Distance Measurement
EDMS	Electronic Data Management System
Ee	Elements table (CPIC Uniclass 2)
EIR	Employer's Information Requirements
ELR	Engineering Line of Reference
En	Entities table (CPIC Uniclass 2)
EN	Euronorm
EOTA	European Organisation for Technical Approvals
EP	European Parliament
EPC	Energy Performance Certificate
EQM	European Quality Mark
ERDC	Engineering Research and Development Center
ETC	Engineering and Technology Board
EUQ	Element unit quantity
EUR	Element unit rate
EVA	Earned Value Analysis
EMP	Early Works Packages

F

FCI	Facilities Condition Index or Function condition indexation
FEE	Fabric Energy Efficiency
FFE	Furniture, Fitting and Equipment
FFL	Finished Floor Level
FIM	Facilities Information Model
FM	Facilities Management
FMA	Facilities Management Association
FMI	Function maintenance indexation
FMP	Forward maintenance plans (or programme)
FFP	Fitness-for-purpose
FRI	Function re-investment indexation
FTP	File Transfer Protocol

No.	
G	
gbXML	Green Building Extensible Modelling Language
GCCB	Government Construction Client Group
GCS	Government Construction Strategy
GDL	Geometric Description Language
GEA	Gross external area
GHG	Green House Gases
GIA	Gross internal area
GIFA	Gross internal floor area
GIS	Geographical Information System
GML	Geography Markup Language
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRIP	Governance for Railway Investment Projects
GSA	Government Services Administration (US)
(G)SL	(Government) Soft Landings
GWP	Global Warming Potential
GUID	Globally Unique Identifier
H	
H&S	Health and Safety
HA	Highways Agency
HMG	Her Majesty's Government
HSE	Health and Safety Executive
HVAC	Heating, Ventilation, Air Conditioning
I	
IAI	International Alliance for Interoperability (now known as buildingSMART)
IAM	The Institute of Asset Management
IBC	Institute for BIM in Canada
IBD	Intelligent Building Data
iBIM	Integrated Building Information Modelling
ICE	Institution of Civil Engineers and Innovative Contractor Engagement
ICIS	International Construction Information Society
ICT	Information and Communications Technology
ID	Identification
IDM	Information Delivery Manual
ie	information exchange
IFC	Industry Foundation Classes

(*continued overleaf*)

No.	
IFD	International Framework for Dictionaries
IFMA	International Facility Management Association
IG	Irish Grid
IGES	International Graphics Exchange Standard
IM	Information Modelling
IMP	Information Management Process
IMU	Inertial Measurement Unit
IPD	Integrated Project Delivery
IP	Intellectual Property
IPI	Integrated Project Insurance
IPP	Initial Project Proposals
IPR	Intellectual Property Rights
IR	Information Requirements
IRMP	Integrated Risk Management Plan
IS	International Standard
ISG	Implementation Support Group (buildingSMART)
ISO	International Organisation for Standardization
IaaS	'Infrastructure as a Service'
IT	Information Technology
IUK	Infrastructure UK
IWMS	Integrated Workplace Management Systems
K	
KPI	Key Performance Indicator
J	
JCT	Joint Contract Tribunal
JIB	Joint Industry Board
JV	Joint Venture
L	
LADAR	Laser detection and ranging
LAM	Laser Aided Modelling
LAN	Local Area Network
LCC	Life cycle cost of life cyle costing
LCie	Life Cycle information exchange
LCR	Life cycle repairs/replacement (renewal)
LCS	Location Coding System (London Underground)
LEED	Leadership in Energy & Environmental Design
LIDAR	Light detection and ranging
LOD	Level of Definition or Level of model Detail (in the US this can be Level of Development)

No.	
LOI	Levels of model Information
LRM	Linear Referencing Method
LRS	Linear Referencing System
LU	London Underground
LZC	Low to zero carbon
M	
MEP	Mechanical, electrical and plumbing
M&E	Mechanical and electrical
M&O	Maintenance and Operations
MIDI	Master Information Delivery Index
MIDP	Master Information Delivery Plan
MWHW	Method of Measurement for Highway Works (Highways Agency)
MPDT	Model Production and Delivery Table
MQC	Model Quality Control
MSG	Model Support Group (buildingSMART)
MVD	Model View Definition
N	
NaaS	'Native as a Service'
NAO	National Audit Office
NBIMS	National Building Information Modeling Standard (US)
NBS	National Building Specification
NC	Numerical Control
NDA	Non-Disclosure Agreement
NDEA	Non-domestic energy assessment
NEC	New Engineering Contracts
NEC3	New Engineering Contract (3rd Iteration of the NEC contract)
NF	National Framework
NIA	Net Internal Area
NIBS	National Institute of Building Sciences (US)
NIEM	Mational Information Exchange Model
NIST	National Institute of Standards and Technology (US)
NMS	National Master Specification
NPC	Net present cost
NPV	Net present value
NRM	New Rules of Measurement
NURBS	Non Uniform Rational B-Spline Surface

(*continued overleaf*)

No.	
O	
O&M	Operations and maintenance
OASIS	Organisation for the Advancement of Structured Information Standards
OBS	Organisation Breakdown Structures
OCE	Order of cost estimates
OCI	Optimised Contractor Involvement
ODA	Olympic Delivery Authority
OGC	Office of Government Commerce
OHLE	See OLE
OIR	Organizational information requirements
OLE	Overhead Line Electrification
OMSI	Operations and Maintenance Support
OPEX	Operational Expenditure
OPS	Outline Procurement Strategy
OR	Operational Rating
OS	Ordnance Survey
P	
PaaS	'Platfom as a Service'
PACE	Property Advisers to the Civil Estate
PAM	Property Asset Management
PARL	Percentage asset remaining life
PAS	Publicly Available Specification
PCI	Pre-Construction Information
PC Price	Prime Cost Sum
PC Sum	Prime Cost Sum
PDM	Project Delivery Manager
PEP	Project Execution Plan
PFI	Private Finance Initiative
PIB	Planned inspection of buildings
PII	Professional Indemnity Insurance
PIM	Project Information Model
PIN	Prior Indicative Notice
PIP	Project Implementation Plan
PIX	Project Information Exchange
POE	Post Occupancy Evaluation
PP	Phases table (CPIC Uniclass 2)
PPC	Project Partnering Contracts
PPM	Planned preventive maintenance
PQQ	Pre-Qualification Questionnaire

No.			
Pr	Products table (CPIC Uniclass 2)		
PSCD	Public Sector Construction Database		
PV	Present value or Solar Photovoltaic		
Q			
QA	Quality Assurance		
QL	Quality Level		
QS	Quantity Surveyor		
QTO	Quantity Take Off		
R			
R&D	Research and Development		
RACI	Responsible, Accountable, Consulted and Informed		
RAG	Red Amber Green		
RCM	Reliability centred maintenance		
RDS	Room Data Sheet (or Room Data Schedule)		
RIA	Regulatory Impact Assessment		
RIAS	Royal Incoporation of Architects in Scotland		
RIBA	Royal Institute of British Architects		
RICS	Royal Institute of Chartered Surveyors		
RFI	Request for Information		
RFID	Radio-frequency Identification		
RFP	Request for Proposal		
RGB	Red Green Blue		
RIT	Room Integrity Testing		
ROI	Return on Investment		
RPI	Retail price index (or indices)	RSL	Reference service life
S			
SA	Site area		
SaaS	'Software as a Service'		
SAP	Standard Assessment Procedure		
SBEM	Simplified Building Energy Method		
SBS	Small Business Service		

(*continued overleaf*)

No.	
SCADA	Supervisory control and data acquisition
SCCS	Supply Chain Capability Summary
SDNF	Steel Detailing Neutral Format
SDO	Standards Developing Organization
SDS	Space Data Sheet (or Space Data Schedule)
SIA	Security Industry Authority
SIL	Safety Integrity Level
SIM	Structural Information Model
SME	Small and Medium Enterprises
SMM	Standard Method of Measurement
SMP	Standard Method and Procedure
Sp	Spaces table (CPIC Uniclass 2)
SPie	Specifiers' Properties information exchange
SPFF	STEP Physical File Format (IFC)
SSL	Structural Slab Level
STEP	Standard for Exchange of Product data
STL	Standard Tessellation Language
Ss	Systems table (CPIC Uniclass 2)
T	
TA	Technical Adviser
TBM	Temporary Benchmark or Tunnel Boring Machine
TER	Target Emission Rate
TIDP	Task Information Delivery Plan
TL	Tube Lines
TLS	Terrestrial Laser Scanner
TOID	Topographic Identifier
TPI	Tender price index (or indices)
U	
UC	Use Case
UK	United Kingdom
UML	Unified Modelling Language
Uniclass	Unified Classification System
UPRN	Unique Property Reference Number
USACE	United States Army Corps of Engineers
UXB	Unexploded bomb
V	
VC	Virtual Construction
VDC	Virtual Design and Construction

No.	
VFM	Value For Money
VPN	Virtual Private Network
VRML	Virtual Reality Modelling Language
W	
WAN	Wide Area Network
WBDG	Whole Building DesignGuide
WBS	Work Breakdown Structure
WIP	Work In Progress
WLC	Whole Life Costing
WR	Work Results table (CPIC Uniclass 2)
WRAP	Waste & Resources Action Programme
WS	Work Results for Specifications (CPIC Uniclass 2)
X	
XML	eXtensible Markup Language
X-REF	Cross reference
XSLT	eXtensible Stylesheet Language Transformations
XSP	Cross Section Positions
Z	
Zz	CAD table (CPIC Uniclass 2)

Appendix C

Digital Built Britain BIM Level 3 Strategy

> This Digital Built Britain strategy takes the next step in integrating these technologies, transforming our approaches to infrastructure development and construction and consolidating the UK's position as a world leader in these sectors. We want to make fully computerized construction the norm and ensure that the benefits of these technologies are felt across the UK and support the export of these technologies and the services based on them. We want to sell our expertise and our cutting edge technologies across the world and seize a share of the $15trillion global construction market forecast by 2025.
>
> (DBB, p. 5)

This document was published by Business Innovation and Skills and the BIM Task Group in February 2015.

While most of our discussion in this *Handbook* has been about Level 2, this was always going to be a stepping-stone.

First, move our complete industry into a digital environment, and then get used to this way of working. Once we've established this, we can then move on to the next levels.

Just as the Level 2 strategy has shaped much of our progress in the UK over the last few years, so too will this Level 3 document perform the same role.

This is now moving us into a joined up digital world, where as an industry we can play our part in the digital and information economy on a global stage. The Internet of Things and Everything is already a reality, we just need to keep up! Level 2 is just the doorway into this world, and the message of the Level 3 strategy is that we need to get a move on!

Look out for further information here: http://www.digital-built-britain.com

Construction Manager's BIM Handbook, First Edition. John Eynon.

Appendix D1

Software: Introduction

As you will know, there is a great deal of 'BIM' software on the market. So a brief section here isn't going to do anything other than scratch the surface.

Much depends on your own situation and what you need to be doing to engage effectively with BIM/CDE environments on your projects.

Before you go spending your hard-earned cash (or that of your employer) on software licences and training, you need to have a clear idea of your requirements and what you need.

The BIM cube (see Chapter 20) will help you to understand your place, role and needs in the project BIM process, and will give you a starter for initial discussions with other stakeholders, your team and software/hardware tech people.

You need to do some analysis on how your organisation works, what information you use or create, how you interact with other team members, how the information flows work and your part in them, and of course begin to think about how this all might work and be improved in a BIM environment. Also discuss this with your clients and other businesses that you work with, to understand how they're implementing BIM and what interests them. This may give you some pointers for your implementation plan.

The BIM Handbook by Eastman *et al.*, has an extensive review of the different software platforms, and is a useful reference.

Software tools can be categorised as follows:

- Authoring
- Federating/viewing
- Analysis/simulation
- Validation/compliance
- Field

Construction Manager's BIM Handbook, First Edition. John Eynon.

- Collaboration
- Apps,

On the following pages I've mentioned a few of the leading players in the UK market, some of whom have provided some further information and case studies in Appendix E.

Summary details

Autodesk

Tools:

- Authoring - Revit
- Federation - Navisworks
- Collaboration – Buzzsaw
- Field – BIM 360
- FM – BIM 360

Website – www.autodesk.co.uk/bimciob
Contact – **01252 456893**

Bentley

Tools:

- Authoring – Microstation for Buildings and Infrastructure
- Federation – Navigator
- Collaboration – Projectwise
- FM – Assetwise
- AECOsim

Website – www.bentley.com

Codebook

Website – www.codebookinternational.com
Contact – Andy Hamer
andy.hamer@codebookinternational.com
M: 07912 869 976
O: 01276 869 282
Skype: andyhamer

Graphisoft

Tools:

- Authoring – ArchiCAD

- Collaboration – BIMx/BIMcloud

Website – http://www.graphisoft.com

Solibri
Tools:

- Solibri Model Checker
- Solibri Model Viewer
- Solibri IFC Optimizer

Website – http://www.solibri.com

Synchro
Tools:

- Synchro PRO
- Planning/programming/timelining (4D)

Website – www.synchroltd.com
Contact – marketing@synchroltd.com

Tekla

Tools:

- Authoring – Tekla Structures
- Federation – Tekla BIMsight

Website – http://www.tekla.com/uk

Vectorworks
Tools:

- Authoring
- Vectorworks Architect
- Vectorworks Landmark

Websites – http://www.vectorworks.net/architect/
http://www.vectorworks.net/landmark/
http://3ddesign.unlimited.com

Vico

Tools:

- Vico Office – Coordination, quantity take off, cost estimation, project schedule and production control

Websites – http://www.vicosoftware.com
http://www.trimble.com

Appendix D2
Collaboration Tools

On most major projects, a project collaboration platform/tool will be used to share information. The whole team, including site managers and operatives and the supply chain, will need to engage with this information portal.

These are accessed online through a standard web browser with a login/password.

The information shared can be models, drawings, schedules, costs, programmes – in fact any information that can be shared electronically – and saves clogging up your email system.

Most of the platforms available in the marketplace contain standard 'workflow' capabilities. This provides some automation of routine processes – for example, issue and tracking of Requests For Information, Technical Queries and Instructions.

The facility to have customised processes made to suit your project or organisation will also be available.

Payment for the service is on a business-wide or project basis, usually calculated on the number of users and/or projects.

Use of these systems can vary widely. I have seen the same system used by different main contractors, one barely scratching the surface, the other making much more use of the system functionality to their advantage.

Immediate benefits of systems like these are that they provide an instant audit trail for the project. You can see who has accessed what information, to whom it has been issued, what is overdue and so on. This is the transparent goldfish bowl of information, which provides accountability and responsibility. If an organisation or individual isn't engaging, then this quickly becomes apparent and can be addressed.

Examples currently on the market include the following. The providers will happily provide demonstrations and training to get you up and running on a project.

Construction Manager's BIM Handbook, First Edition. John Eynon.

You can find further details and make contact at these websites:

4 Projects	http://www.4projects.com
Aconex	http://www.aconex.com
Asite	https://www.asite.com
Basestone	http://basestone.io
Buzzsaw	http://www.autodesk.co.uk/products/buzzsaw/overview
Conject	https://www.conject.com/uk/en/index
Projectwise	http://www.bentley.com/en-GB/Products/projectwise+project+team+collaboration/

oakwoodengineering
modelling the future

Appendix E1

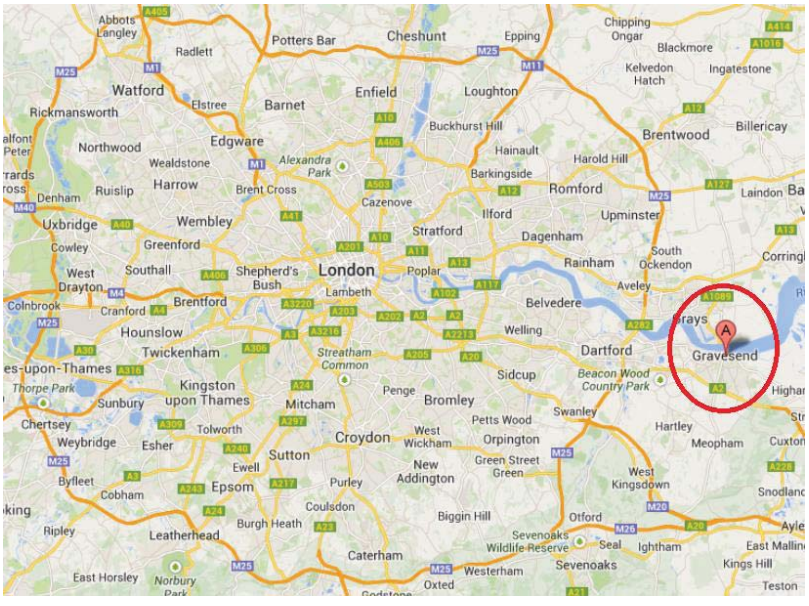
Synchro Oakwood 4D Model Case Study

Project: Gravesend Station Remodelling

15 Day Full Blockade: 22nd December 2013 to 6th January 2014

Gravesend railway station serves the town of Gravesend in north Kent. The station is 24 miles from London and the train services are operated by Southeastern Rail.

Construction Manager's BIM Handbook, First Edition. John Eynon.



The station is situated on a major commuter line into/out of London, and the high-speed HS1 services to London St Pancras International were introduced in December 2009. The station is now seen as a major interchange for metro and high speed services. There is also potential for the Crossrail project to be extended to Gravesend.

The station's remodelling will allow 12-car trains to stop at Gravesend which would provide up to 3,500 extra seats and more space for passengers.

The team

Client: Network Rail
Contractor: C Spencer Ltd
4D Consultants: Oakwood Engineering/Schofield Lothian

Project summary

Scope of works

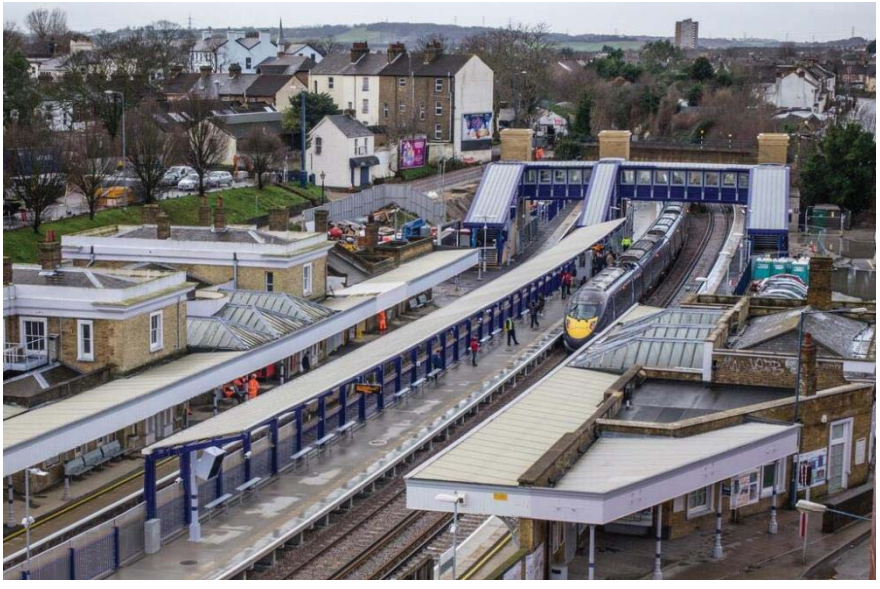
- Value: £19.137m
- Remodel track layout throughout the station
- Remodel signalling layout throughout the station
- Construct a new Island Platform & Canopy
- Extend existing Platforms 1 & 2

- Remove the existing footbridge and water tower base (Pre-blockade works)
- Construct a new AfA compliant footbridge with lifts serving all platforms (Partial pre-blockade works)
- Modular Control System (MCS inc TD & SPAD alarms) changes at Ashford IECC
- Solid State Interlocking (SSI) changes (NG & NH) interlocking areas
- Cab Secure Radio (CSR), GSM-R and ARS changes to reflect new layout
- Interface with CTRL Route Control Centre System (RCCS) for services to HS1
- Enhanced Station Systems (PA, CCTV, DOO, CISS etc.)

Blockade volumes

- Total new track – 982 m
- Total new sleepers – 1060
- Total new ballast – 5000 m^3
- Total conductor rail realigned – 400 m
- Total conductor rail renewed – 1463 m
- Total number of S&C – 1 Turnout (2254 Point No., CV Switch, IBCL, Concrete Layout)
- Total length platform extensions – 120 m
- Total length of new island platform – 275 m
- Total DOO cameras and screens: Recover 25 DOO Monitors and install
- 32 Monitors and Recover 13 Cameras and install 20 cameras

Before



After

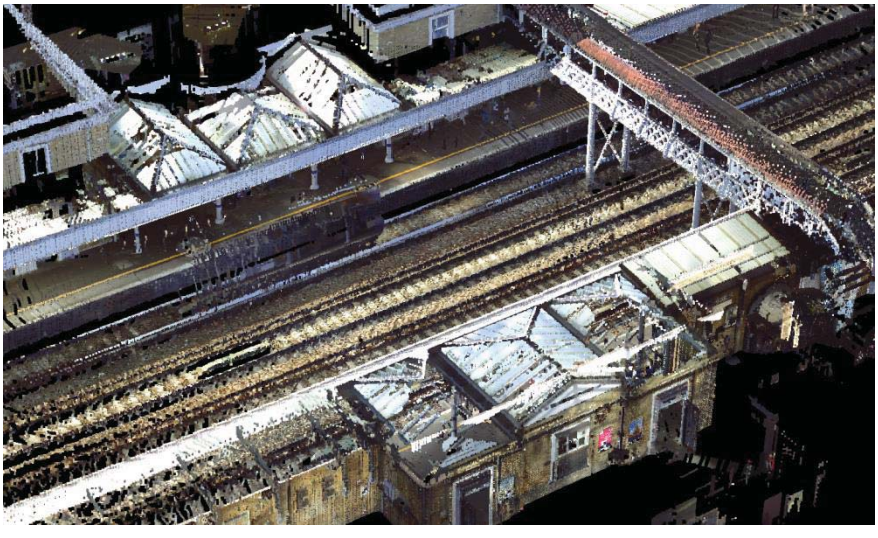
Selection of 4D modelling for Gravesend Station

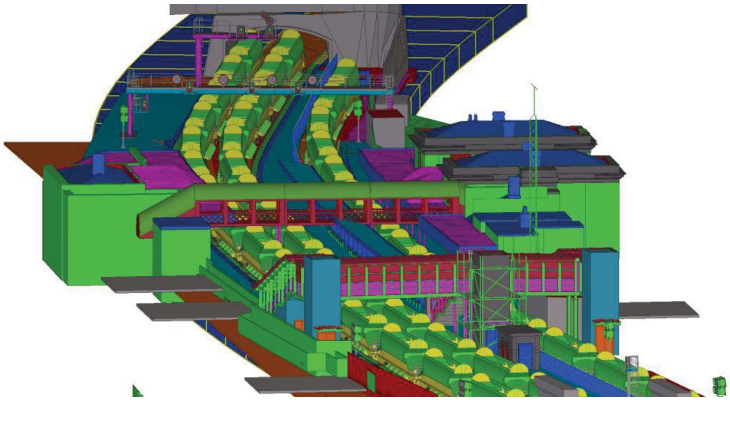
The project team felt a requirement to embrace new techniques given the complexity and high-profile nature of the project. The emphasis and primary purpose of the 4D Virtual Construction Model was to de-risk the 15 Day Blockade in terms of construction/build as well as a tool to enhance the 'standard' safety measures to protect the workforce.

Scope of works

A joint venture team of Oakwood Engineering and Schofield Lothian were appointed to undertake the works. With only 2D data available, the following formed the scope of works:

- Carry out detailed laser scan survey of the station to capture existing state.
- Create 3D model from the laser scan data.
- Source Lidar survey model of the Gravesend area.
- Produce accurate 3D models of all permanent works, temporary works, plant and logistics.
- Integrate all 3D data with the P6 programme using Synchro Software.
- Review 4D model and report conflicts.
- Facilitate model based project review meetings.
- Facilitate model based safety review meetings.
- Maintain the 4D model in line with programme revisions.

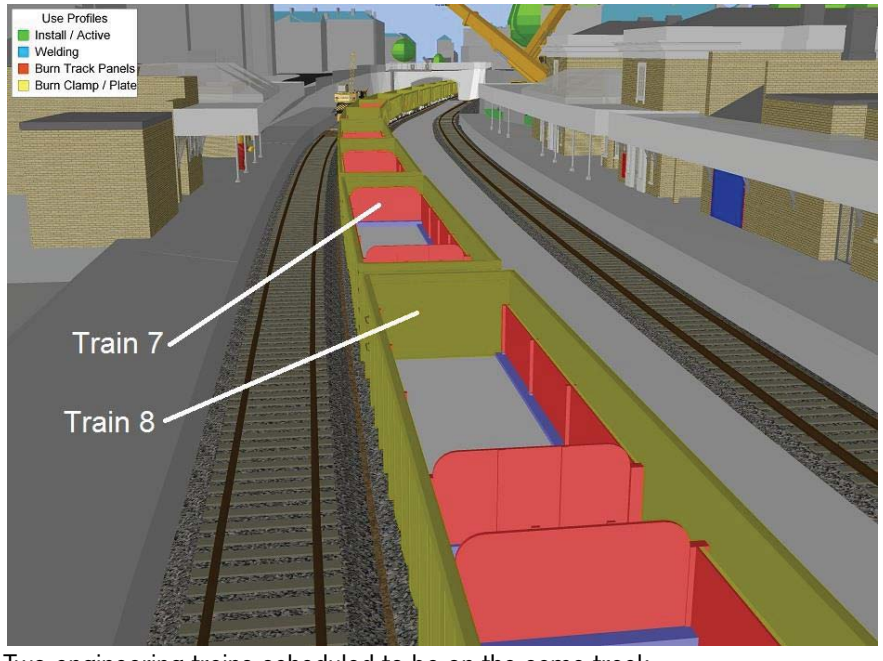




- Create snapshots/animations to inform project stakeholders, the train operating companies (TOC) and the public.
- Provide onsite training to the project delivery team.

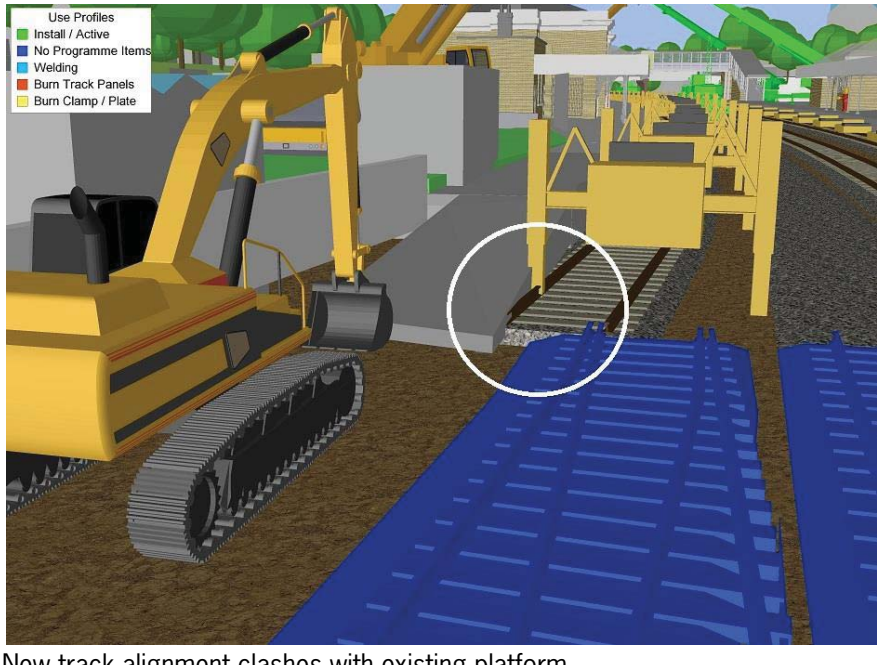
Verification and viability of build schedule and sequence

A number of dynamic clashes were found during the review process and therefore any potential delay was mitigated. Below are some examples:



1. Two engineering trains scheduled to be on the same track.

2. Track to be repositioned using PEMs clashes with an engineering train.

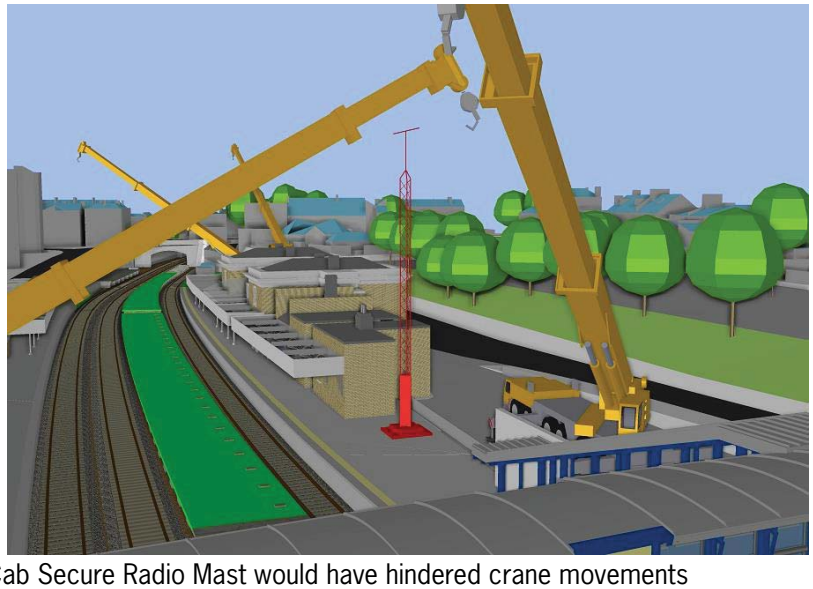


3. New track alignment clashes with existing platform.

4. An engineering train to be positioned on incomplete track.

4D workshops

'Nuts & Bolts' Construction Meetings: the 4D Model was utilised on a weekly basis as a central discussion tool in order to challenge/confirm the constructability of the scheme along with the logistics planning of the plant, materials and work gangs.



The Cab Secure Radio Mast would have hindered crane movements

An example of a build sequence clash is shown in the image below. The Cab Secure Radio Mast at Gravesend Station was only realised as an obstacle to the crane lifting plan late in September 13. Although this was not a new obstacle it was not till the 'craneage' was modelled that the CSR mast was seen as being a 'clash' which significantly reduced the crane movements. The CSR Mast removal was introduced into the 15 Day Blockade hour by hour programme as one of the first activities thus allowing the full crane movements to remain as per the original schedule.

15 Day Blockade Workshop: the 4D Model was utilised within a number of workshops as the reference for the Forum to challenge the scheme assumptions, programme and safety regime.

15 Day Hour x Hour Programme Walkthrough: the complete project delivery team (Network Rail, Spencer Rail & Southeastern Rail) of 70 members participated in a workshop where all disciplines recalled the hour by hour activities from memory over the 15 Day Blockade.

An hour by hour walk through (as pictured above) was carried out with 70 team members in attendance.

The planned vs actual snapshot highlights a programme inefficiency spotted during the hour by hour walk through. The central platform steelwork was programmed to arrive at site on the morning of 26 December. However, the team pointed out that they were expecting this steelwork on the evening of 27 December. After a 30-minute 'programming' break, the updated P6 programme was synchronised with the 4D model and the correct sequence was in place.

Planned v Actual – Steelwork to central platform delivered 36 hours early

A further example of a programme logic error was found during a meeting, just one week before the blockade. The model showed that the removal of the existing signal gantry, a critical path task, would take place in the afternoon of 22 December. Its removal should have been shown in the morning of 22 December. It transpired that the crane rigging times were not factored into the programme which would have added significant delay and knock on impact for the craneage.

Removal of signal gantry was programmed 4 hours too late

Given the impact of the engineering trains and cranes, the materials delivered by rail and road had to be re-scheduled where appropriate or re-sequenced to accommodate.

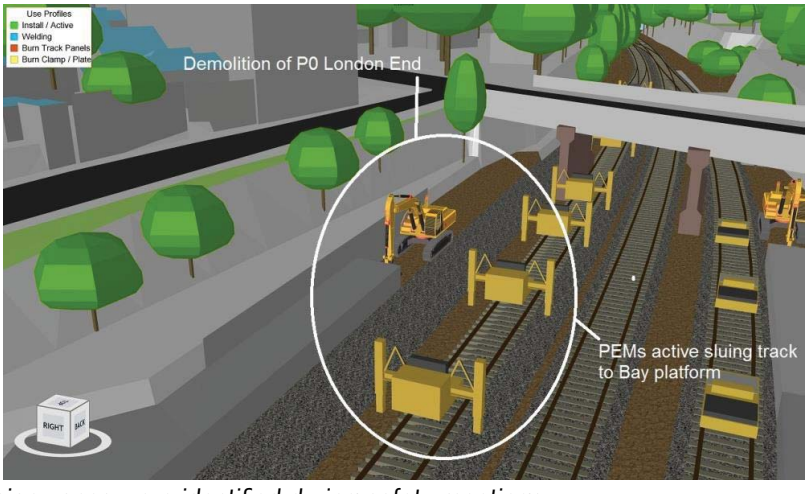
The position and activities of the work gangs also underwent several iterations given the impact of the engineering trains, cranes and material deliveries. The programme was rescheduled where appropriate or the work activities were re-sequenced to accommodate.

Safety meetings

15 Day Hour x Hour Safety Walkthrough: the project delivery team (Network Rail, Spencer Rail & Southeastern Rail) supplemented with additional H&S team members participated in a workshop where the entire 15 days were analysed/scrutinised on an hour by hour and work zone basis in order to verify and/or modify the safety regime for the blockade.

The 4D Model was used to have a full safety review which resulted in implementing additional safety staff and methodologies. 'Safety zones' were identified and 'safety supervisors' were appointed who were dedicated for each area.

Other additional safety features were identified with appropriate solutions implemented. The snapshot below shows an example of this. Track realignment was taking place adjacent to platform demolition works. The use of PEMs requires exclusion zones so these works could not be carried out simultaneously.



Exclusion zones were identified during safety meetings

Signal sighting

The Project sighted an instance where the 4D Virtual Construction Model played a small but significant part in the form of 'signal sighting'.

The lead up to the 15 Day Blockade included a number of weekend track possessions one being week 34 (16/17 November 2013) when the new AfA Footbridge was being placed at the London End of the station. A few days prior to this significant event and milestone, the signal sighting of NK438 (London End Up Main) was brought into

question regarding the driver's line of sight when the single span AfA Footbridge was in position. This jeopardised the placement of the AfA Footbridge prior to the 15 Day Blockade. If indeed the signal sighting of NK438 was infringed, the AfA Footbridge would have to be deferred to the beginning of the 15 Day Blockade which in turn would increase the work load during this period.

The 4D Model was used to provide evidence to the Signal Sighting Committee that the 'sighting' of signal NK438 was not jeopardised with the AfA Footbridge span allowing the AfA Footbridge placement to proceed as planned during wk34.

Signal NK438 could be sighted under the new footbridge

Further uses

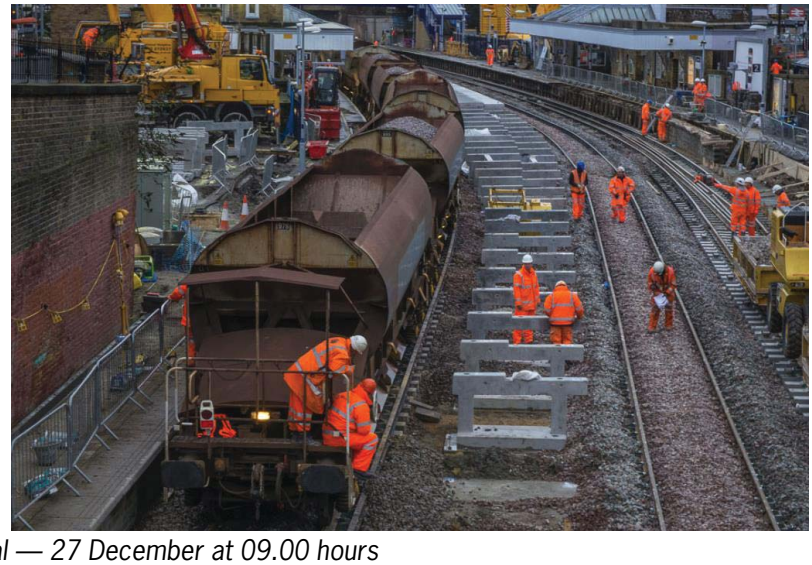
- As a concise and easily visualised representation for inductions. One such meeting was held at the Town Hall to 450 people.
- To present to Senior Management, Southeastern Rail Management, Dartford Maintenance Delivery Unit, Freight Operating Companies, Ashford Signalling Control Centre, Southeastern Train Driving Team, Eurostar and HS1.
- To present to Kent County Council Road Management Team and Gravesham Borough Council. Road closures, car park closures and haulage plans were accepted on the first applications.
- PR tool – an animation of the full works was created to be played on the platform information screens prior to the blockade and Southeastern Rail's website.
- As a central theme for circa 30 project review meetings and 12 meetings with the Station Manager/staff. This allowed them to explain the impact and benefits of the blockade to the customers.
- The model was used as an 'aide memoir' to brief workers at the start of their shift.

The blockade

Following a period of calm weather in December, the blockade was beset by gale force winds and heavy rain during the first three days. This resulted in an overall loss of **100 hours**.

The 4D model was used as key tool to mitigate against this bad weather. Segregated work zones were identified and the model helped recognise the ground works that could proceed with the high winds which 'stopped the carnage'. The hours were steadily 'pulled' back (see images below) through re-scheduling – a process that was very efficient as all parties were aware of the work interfaces via the 4D Model.

Planned — 27 December at 05.00 hours



Actual — 27 December at 09.00 hours

Project outcome

Gravesend Station was completed **on schedule** with the first passenger train leaving the station at 04.33 hours on the 6 January 2014. Below is a summary of the blockade statistics:

- 2,500 crane lifts
- 900 people involved
- 92,000 working hours
- 789 Deliveries to site
- **No** lost time injuries
- **No** RIDDORs – Reporting of Injuries, Diseases and Dangerous Occurrences Regulations
- **No** Lineside Neighbour Complaints

The on time hand back ensured that the project did not suffer any penalty costs or overrun expense. Below is a summary of these potential costs:

- Cancellation of trains – **£1.35 m/day**
- Maintaining/extending the rail replacement service – **£125,000/day**
- Cost to continue works – **£150,000/day**

Safety completion ensured that the project did not suffer any lost time as indicative figures show:

- Site Investigation of minor injuries @ 3 hours
- Site Investigation of 'lost time' RIDDOR @ 6–12 hours
- Site Investigation of a major RIDDOR @ 24 hours
- Site Investigation of a fatality – site close down

Each of the above investigations will have associated costs along with reputational cost, programme costs and any potential litigation.

Conclusion

The 4D model achieved its goal of de-risking the 15 day blockade by creating a collaborative environment and allowing the team to make proactive decisions. It was also pivotal in driving the remedial actions and ensuring on-time completion.

David Lindsay, Senior Project Manager for Network Rail, commented 'We were successful in avoiding any delay in hand back through using the 4D Model'.

A vote was conducted at a post blockade Steering Group Meeting on the usefulness of the 4D model and whether the team would employ a 4D Model on the next project – there was an overwhelming vote of **Yes!**

SYNCHRO SOFTWARE

Appendix E2

Synchro HARBORcenter Case Study

The 4D Synchro model for the HARBORcenter project was initially developed during the pursuit efforts of the project. This model was created in collaboration with the design team and HARBORcenter Development for the proposal presentation. HARBORcenter is a multi-use facility located in downtown Buffalo, New York. Once opened, this facility will host an elite-level training academy for hockey athletics in both the United States and Canada.

The facility includes a five-level above-grade parking structure, two NHL-quality ice sheets, a sports bar and grill on ground level, two tenant spaces, and a full-service, 200-key, Marriott Hotel. The project was scheduled to have a phased occupancy: September of 2014 for the Parking/Ice Program and May of 2015 for the Hotel.

Still under construction, the project's Synchro model is maintained on a weekly basis to support schedule visualisation for the OAC meetings and the weekly subcontractor meetings. Additionally, the weekly Synchro model update was defined to align with the weekly schedule update performed by the onsite scheduler and project superintendent. Recent model updates include the addition of site logistics items, notably the material hoist on Main Street and the concrete placing boom for the hotel tower, and the inclusion of the second shift schedule.

Additionally, the model has been shared with the Owner's group, and has been utilised by the Buffalo Sabres' NHL team during pre-game and intermission commercials. Mortenson provided an AVI export enabling the Sabres' communications

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team to incorporate the construction visualisation into the overall project marketing efforts.

HARBORcenter's Synchro model on the first Niagara Center centre-hung scoreboard

Catenary pole relocation

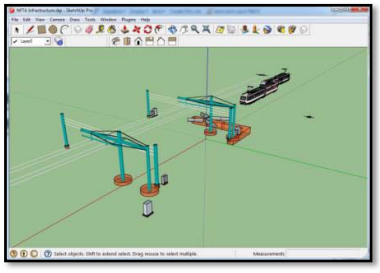
The HARBORcenter project required the relocation of two light-rail catenary support poles, a switch heater box and a control box. These four elements are currently located on the Webster Block, and within the proposed building footprint. The Mortenson team prepared 3D models used at work sessions with the Niagara Frontier Transportation Authority and the subcontractors involved in the system relocation, to plan the correct approach to this work. Through this exercise, constructability was addressed.

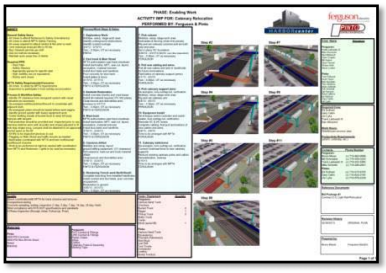
By modelling this scope of work in the design development phase, the project team was able to discuss the installation process with the design team and subcontractors. Additionally, it permitted the team to engineer-out safety concerns of the NFTA, schedule system outages, and clearly define the plan of work.

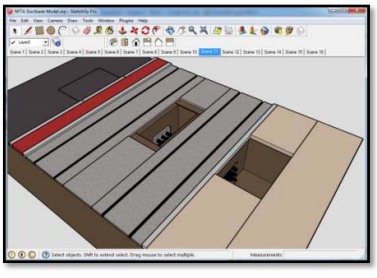
At the conclusion of this exercise, a 3D sequenced model was established to represent the workflow of the relocation and contribute to the development of this scope of work's Integrated Work Plan. Additionally, components of this model were later incorporated into the 4D model in order to ensure communication efforts and overall coordination between site activities and the relocation schedule.

Steel and concrete interface

The 4D model developed for the HARBORcenter project has recently been utilised to provide schedule visualisation of the sequence of the activities associated with the interface of the structural steel system with the concrete system at the hotel tower.

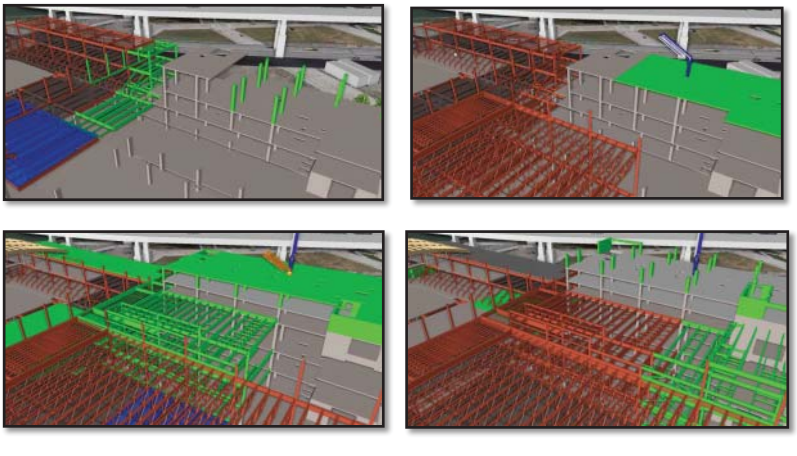




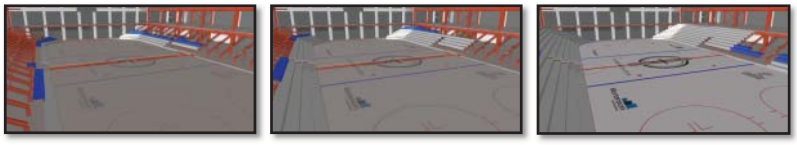


Clockwise (from bottom left):
Duct bank Installation Virtual Mockup
Light-Rail Cantenary Relocation Model
Cantenary Relocation Integrated Work Plan

This model helped review how Mortenson plans to place the Level 6, 7 and 8 post-tensioned decks in two halves. This approach is necessary in order to align the concrete sequence activities with the structural steel erection sequence, notably sequence 7, 9 and 10. This exercise not only helped in the visual review of how the PT deck will sequence from the garage into the hotel tower, it also ensured accuracy in schedule management at this structural interface by validating the ongoing coordination efforts between these trades.



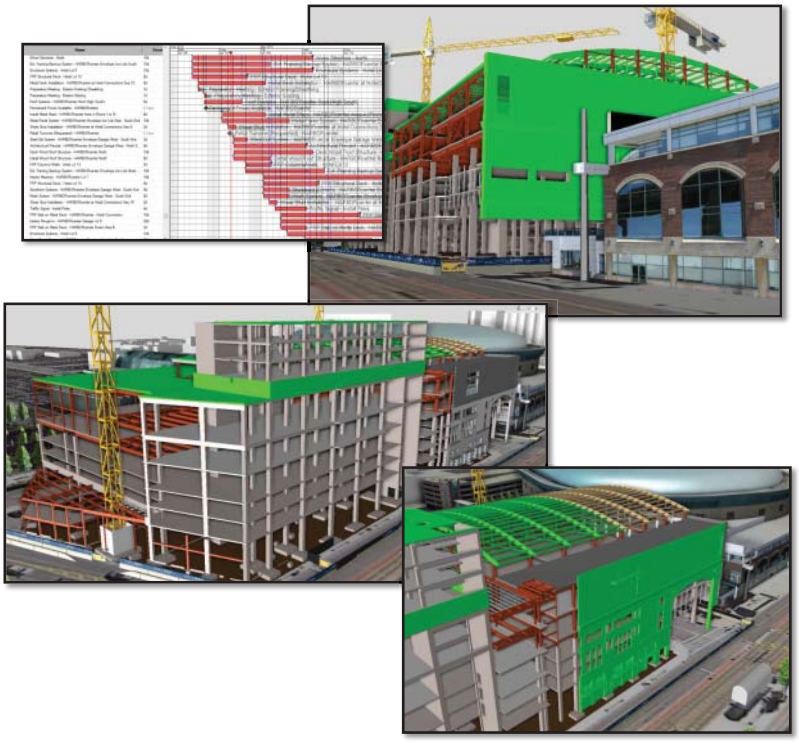
Other schedule visualisations include the stadia seating sequence. This model will be used to evaluation the construction logic and further define the schedule activities associated with the cast-in-place stadia at sheet #1.



Enclosure analysis

Four-dimensional modelling is utilised on the HARBORcenter project in order to evaluate and enhance the enclosure sequencing in the CPM schedule. In order to generate the 4D environment for the project team's use, the current CPM schedule is imported into a program which pairs model elements with the associated schedule activities. Through this exercise, the superintendents can visualise the schedule logic, while reviewing spatial constraints of concurrent activities. With the ability to fly around the model, and adjust the time-scale, the user is able to evaluate workflow and edit the schedule, validating alternate logic and sequencing.

As schedule tasks reach a higher level of detail, the model components can be re-associated in greater detail, permitting an updated interface for follow-up evaluation.



AUTODESK.

Appendix E3

Autodesk Case Study: The New Way of Working

Team uses BIM to improve coordination, buildability, operability, and maintainability on a £150 million wastewater treatment plant expansion project

Image courtesy of Galliford Try Costain Atkins

Introduction

A joint venture partnership of Galliford Try Costain and Atkins (GCA JV) is currently completing work on a £150 million expansion of the Liverpool Wastewater Treatment Works. The joint venture was specifically set up to deliver detail design and construction for United Utilities Asset Management Programmes, and has been in partnership with the company for over 12 years. The completed Liverpool programme will provide the works with the capacity to deal with 960 mega-litres per day, serving the needs of more than 600,000 people.

Rather than rely on the traditional 2D workflows for detail design of this flagship project, the GCA JV Board of Directors recognised that the delivery of the project could

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be greatly enhanced by employing Building Information Modelling (BIM). As civil and structural detail designers for the project, Atkins, one of the world's largest engineering consultancies, with more than 100 offices in the United Kingdom, was charged with leading the implementation of the BIM strategy.

According to Paul Heath, BIM lead adopter for Atkins Water Operations, BIM has proved to be a time- and cost-saving asset on the project: 'A BIM process is built around 3D models, and helps the whole team to better understand the project before and during construction. Large, complex projects progress with fewer issues when you use BIM. There were numerous instances of problems avoided and value engineering opportunities recognised early in the design stages of the project, which greatly contributed to cost savings.'

BIM leads to significant time and cost savings

The challenge

The client, United Utilities, was responsible for the concept and definition phases of the project, with GCA JV taking over for the implementation phase and providing detailed design and construction services. A number of complexities stood out on the project. The new plant is located in an existing operational dock, which is subject to a preservation order by English Heritage. This meant that the design had to avoid damage to the walls. The dock was also still operational, so the gates had to be closed and a permanent closure constructed prior to dewatering, sand infilling and piling.

'A facility of this type and size would typically occupy a huge swath of land,' says Heath. 'You expect acres of space to work with, but on this project the footprint is very confined. The solution was to go up rather than out, so there are eight treatment cells over another eight treatment cells. We thought that designing in 3D could help us manage all that complexity, and that using Autodesk® Navisworks® Manage software could help us coordinate all the models required by the project.'

Image courtesy of Galliford Try Costain Atkins

The solution

Starting with the main SBR (sequence batch reactor) structure, the design team created a 3D model of the piles, base and wall starters, cutting 2D plans and sections

from the model using Autodesk® AutoCAD® and Autodesk® AutoCAD® Plant 3D software. The 2D drawings were then sent to the Global Design Centre in India for reinforcement detailing. The speed demonstrated in this 'new' workflow helped to quickly allay any concerns that designing in 3D would slow down the production of the 2D construction drawing deliverables.

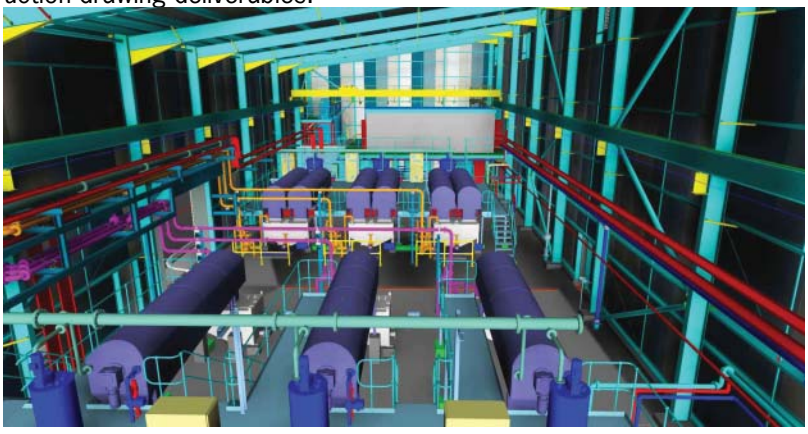

Image courtesy of Galliford Try Costain Atkins

Matt Lees, BIM specialist for Atkins, explains how the design team overcame reluctance to use BIM. 'We designed in 3D from the outset, and then generated 2D drawings from the models,' he says. 'Those who were hesitant saw that you can easily create a 2D drawing from the 3D model if you need one. People realised they could get the advantages of 3D without a downside.'

'Interestingly, we did have a few project participants who chose to use 2D workflows against our advice or requirements,' adds Heath. 'It's been a relatively issue-free project, but those 2D-based processes have been a large part of the few issues that we have encountered.'

A coordination hub

On a project the scale of the Liverpool Wastewater Treatment Works, there are dozens of participants, with subcontractors and the equipment supply chain submitting detailed models and designs for their particular elements of the project. The detailed design itself even involved an Autodesk® AutoCAD® Civil 3D® model, which was used with barometric survey data to help calculate silt volumes contained in the dock prior to construction commencement. The team also used Autodesk® Navisworks® Manage software to create a federated model of the project for coordination and design review. The team used the model to engage partners, suppliers and the client's operations personnel early in the design process to help provide a more optimal solution.

'We brought more than 450 models into Navisworks,' says Lees. 'Navisworks handles far more than just Revit or Plant 3D and AutoCAD. Vendors sent equipment models created in Autodesk® Inventor® and SolidWorks® software. Having the model helped us to design out potential clashes early in the process.'

Lees adds that: 'The model helps us design for improved constructability and more efficient operations and maintenance. Using the model as a reference, operations staff from the client helped us understand how to optimise the plant for maintainability and safety. When we're done, the utility will have a virtual plant in Navisworks to which we can add equipment details to facilitate asset lifecycle management.'

Using a 4D model helped to sequence construction in advance

Modelling infrastructure construction and beyond

The GCA design and construction team turned to Navisworks Manage again when it came time to plan construction. They linked the model to the construction schedule and created a 4D construction plan. As the project has moved to the field, the team is still using the model. Autodesk® BIM 360™ Field software lets the team refer to the Navisworks model on Apple® iPad® mobile devices at the point of construction. Using BIM 360 Field aids the team's efforts to monitor and resolve construction, installation, commissioning and health and safety issues.

In addition, the Navisworks model was used by organisations in the supply chain for pricing exercises. Rather than using a labour-intensive process of developing traditional 2D drawings, suppliers were encouraged to measure from discipline-specific models that showed design intent. This helped reduce the risk of measurement errors, contributing to improved accuracy and leaner pricing. The successful suppliers were contracted to supply their own detailed design models, which replaced the design intent models.

'We coordinated and sequenced construction well in advance,' says Heath. 'The 4D model let us rehearse the construction and helped us look for ways to reduce costs, improve safety, and work more efficiently. For instance, the model proved invaluable as we value engineered the pumping station. The changes resulted in cost savings. Using a model helped afford us the opportunity to improve buildability, operability and maintainability at the same time.'

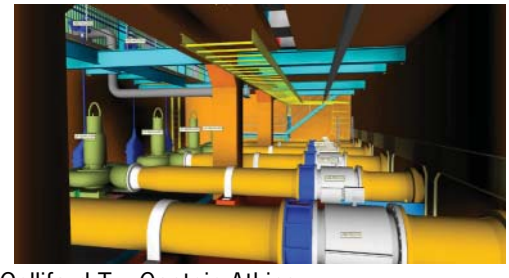

Image courtesy of Galliford Try Costain Atkins

The result

As the project advances to completion, the team is pleased with its implementation of BIM. 'A model is useful at the beginning of a project, during construction, and later during operations,' says Heath. 'Working in 3D became the norm for the team very

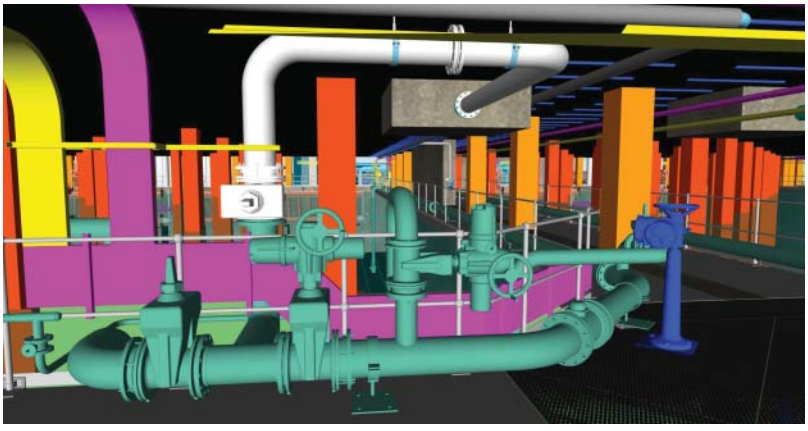

Image courtesy of Galliford Try Costain Atkins

quickly. We estimate that it has helped to save hundreds of hours on design alone and the improved coordination is also helping to reduce costs. On a project of this size and complexity, up to a hundred clashes would probably be a conservative estimate with a traditional 2D workflow. If you assume each undetected clash could cost you about £1000 in lost time and rework, then you are looking at major savings through clash detection supported by Navisworks Manage.'

The success of BIM implementation was ably demonstrated by the recent completion of 386 m of large-diameter process pipework ranging from 1600 mm to 2200 mm. The pipework was designed in the BIM model, fabricated off site, and installed between a number of fixed points with no on-site cutting.

Referring to the pipework as an example, Lees noted, 'This is a true testament to collaboration between design and construction. Working closely with the BIM design team, GCA Site Engineering carefully monitored each invert level, centreline, and pipe rotation. We were able to interrogate the model at any point during construction, giving our site supervisors the information they needed to replicate the 3D model. It's also good to know that there will be no work to do on the as-builts for these pipes, other than altering the drawing's revision.'

Appendix E4

Bentley Case Study: Dŵr Cymru Welsh Water Deploys Bentley's ProjectWise to Improve Team Collaboration

Handles water system information and reduces costs

Dŵr Cymru Welsh Water (Welsh Water), a regulated company providing water supply and sewerage services to over 1.3 million households and businesses in Wales and parts of England, is deploying Bentley's ProjectWise project team collaboration and work-sharing platform. Its goals for this new deployment are to enhance the ability to manage all of Welsh Water's engineering content and to reduce associated costs.

Welsh Water operates 68 source reservoirs and 68 water treatment works, and supplies an average of 823 million litres of water every day through a network of 27,100 kilometres of water mains that includes 532 pumping stations and 654 service reservoirs. It also collects wastewater (including surface water) through a network of 36,000 kilometres of sewers that incorporates 1,700 sewage-pumping stations and 3,300 combined sewer overflows. The wastewater is then treated at 835 wastewater treatment works located throughout the company's operational areas.

A secure, managed environment for engineering content

In its continuing drive to further enhance its customer service and business efficiency, Welsh Water was determined to better manage its engineering content, including all of its documentation and data sharing. To help achieve this, Welsh Water is deploying ProjectWise to create a secure, managed environment in which its engineering documents can be stored. As part of the deployment, Bentley and Logica (one of Welsh Water's IT

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partners) have developed and implemented the documentation infrastructure and have trained staff to use ProjectWise. Kelvin Davies, GIS applications manager, Welsh Water, explains, 'Implementing ProjectWise greatly assists the business to efficiently manage the large volume of engineering related documents required by various disciplines to update and upgrade spatial data.'

Taking on 22,000 additional drawings

The immediate implementation of ProjectWise is being driven by new regulations in England and Wales. The Department for Environment Food and Rural Affairs (Defra) and the Welsh government have determined that private sewers and lateral drains become the responsibility of the water companies. As a result, Welsh Water has taken over responsibility of an additional 17,000 kilometrrs of private sewers and drains in October 2011. Dave Collins, asset capability manager, Welsh Water, comments, 'We have around 17,000 engineering documents, mostly in legacy formats, which will need to be geo-referenced, managed, digitised, and added to the existing geospatial information system (GIS) data.' An additional 5,000 Section 104 sewer adoption agreements, all of which have as-laid drawings of sewers, will also be added to the GIS. Collins points out that, 'With the help of ProjectWise, Welsh Water will be able to access this engineering information, including the additional documents, through a map-based interface, enhancing our ability to efficiently and effectively manage this data.'

ProjectWise: create and entrust critical AECO content

Improved management of hydraulic models

In recent years, Welsh Water has invested in creating calibrated hydraulic models of large sections of its potable water and wastewater networks. This enables Welsh Water designers to work through various scenarios, such as testing the effects of adding new properties or developments to the existing infrastructure. Enhanced management of their hydraulic models will provide efficiency improvements to Welsh Water. Version control of these models has been a challenge for Welsh Water and the implementation of ProjectWise will help the business to manage centralised workflows to keep these models up to date.

Getting more from ProjectWise

Moving forward, there are many ways for Welsh Water to benefit from its use of ProjectWise. In addition to the engineering documents and sewer adoption agreements that are part of the private sewer transfer, Welsh Water also receives a huge amount of as-constructed documentation. All of this engineering-related content needs to be brought into the document infrastructure and the GIS records, subsequently, will need to be updated. In addition, Welsh Water has serviceability measures that it has to maintain throughout the year, including water quality, customer service and levels of performance. Welsh Water uses its GIS to map failure data and investigative data in relation to serviceability. ProjectWise will also assist with the management of documentation in this area.

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