AUTHOR(S): KOUIDER, T., PATERSON, G. and HARTY, J.

TITLE: Architectural technology and the BIM acronym 3: getting to grips with BIM.

YEAR: 2016

ARCHITECTURAL TECHNOLOGY AND THE BIM ACRONYM 3: GETTING TO GRIPS WITH BIM

TAHAR KOUIDER, GRAHAM PATERSON
Robert Gordon University Aberdeen UK
t.kouider@rgu.ac.uk
UrbhanStudio Glasgow UK
urbahnstudio@gmail.com

AND

JAMES HARTY
Copenhagen Technical Academy Denmark
jmh@kea.dk

Abstract. Among Small and Medium Sized Enterprises (SMEs) in particular, the UK Government's ambitions regarding BIM uptake and diffusion across the construction sector may be tempered by a realpolitik shaped in part by interactions between the industry, Higher Education (HE) and professional practice. That premise also has a global perspective. Building on the previous 2 papers, Architectural technology and the BIM Acronym 1 and 2, this third iteration is a synthesis of research and investigations carried out over a number of years directly related to the practical implementation of BIM and its impact upon BE SMEs.
First challenges, risks and potential benefits for SMEs and micros in facing up to the necessity to engage with digital tools in a competitive and volatile marketplace are discussed including tailoring BIM to suit business models, and filtering out achievable BIM outcomes from generic and bespoke aspects of practice.
Second the focus is on setting up and managing teams engaging with BIM scenarios, including the role of clients; addresses a range of paradigms including lonely BIM and collaborative working. The significance of taking a whole life view with BIM is investigated

including embedding soft landings principles into project planning and realisation. Thirdly procedures for setting up and managing common data environments are identified and the value of achieving smooth information flow is addressed.
The overall objective of this paper is to provide SMEs with a practical strategy to develop a toolkit to BIM implementation.
Keywords: *BIM, Implementation, Collaboration, Workflow, Toolkit, Data.*

1. Scene setting

The overarching intention with this paper is to offer a practical and grounded approach which will assist small organisations and educators in getting to grips with key principles and practical applications for collaborative working using digital tools. For example what strategies are necessary to set up and document an organisation's first steps towards a BIM project? By following a pathway, which focuses on basic principles and first steps, there is total commitment to the idea that BIM is not just applicable to the delivery of large and complex building and infrastructure developments. The authors maintain that the structured and efficient use of digital data is equally valid for developing small projects and will argue that case consistently throughout this paper.

2. Tailoring BIM for SMEs

2.1. CHALLENGES, RISKS AND POTENTIAL BENEFITS FOR SMES AND MICROS

The transition to a BIM collaborative working environment poses a number of challenges, risks as well as benefits for small and medium enterprises in the constructions sector as whole. The technology gap within the construction industry continues to widen between large companies and SMEs / micro-SMEs. Amongst the former, Information and Communication Technology (ICT) is pervasive and has become a key infrastructure covering all aspects of business including design, construction, asset management, life cycle, marketing, cost management

etc. Amongst the latter however, ICT is often limited to traditional 2D drawings, perhaps some static 3D visuals, email and possibly a symbolic internet presence. The status quo creates a divide in the industry and potentially may lead to a Macro versus Micro effect that will certainly hamper any effort for collaboration within the industry

Access to BIM by SMEs and in particular micro SME's tends to be hampered by a lack of ICT infrastructure as an enabler to a quick deployment of BIM. Working in a dynamic workflow is a major shift in working practices and extends beyond acquiring expensive hardware and software. A radical change of attitude and work practices is required to work in this dynamic and collaborative environment. Furthermore, the learning curve is lengthy and demands sustained training and up skilling of personnel as well as changes to organisation's business model. A recent study by the authors examining BIM as a collaborative tool concluded that contrary to literature claims, a case study has shown that the present investment, in terms of time, cost, and effort required to implementing the technology means that BIM is unlikely to be adopted on small simple projects or by micro-SME's where conventional CAD is adequate.

The burden of the additional expenditure is not insignificant in a highly competitive and difficult economic climate in which small businesses are often struggling to stay afloat. The unclear time scale of return on investment makes it even more difficult for SMEs to make substantial financial commitments as highlighted by BIM4SME:

"Moreover, as the group are SMEs themselves the equation of cost is foremost in our minds, but perhaps the more important question is 'what do I get for my money, what are the benefits and how long before my investment is paid off."

Embarking on a BIM implementation process is not only a daunting task but carries considerable risks from a business viewpoint. SMEs do not possess the financial resilience of larger organisation to be able to absorb potential losses nor dedicate significant resources be they financial, human or time. Failure of very careful planning, getting it wrong could mean business ruin. It is these risks and challenges that call for careful planning and gradual implementation of collaborative BIM together with strategic and technical support for SMEs.

Despite the above risks and challenges, we strongly believe that a managed transition to Level 2 BIM and beyond offers sound benefits for

SME from both a pragmatic business viewpoint and most importantly the long term readiness and resilience for a rapidly changing construction industry.

Level 2 on the BIM Maturity Index (Figure 1) assumes that everybody ought to be operating at the very top end by 2016. What is the level of progress towards this goal? The reality is a mere guess, particularly amongst the big majority of small companies across all built environment professions. It remains difficult to build a full picture of the level of true understanding and implementation due to the lack of reliable data and limited take up of BIM surveys. Recent surveys tend to be unrepresentative due to the small number of respondents. For instance, the National Building Specifications (NBS) survey received 1500 respondents in contrast to thirty thousand RIBA members. Despite the low intake in these surveys, the results do not provide an encouraging reading; the National Federation of Builders (NFB) survey provides an insight into the state of readiness of construction SMEs in relation to level 2 BIM uptake. Of all contractors surveyed only 30% work with electronic 3D drawings, 54% of which are large contractors and only 25% are SME contractors.

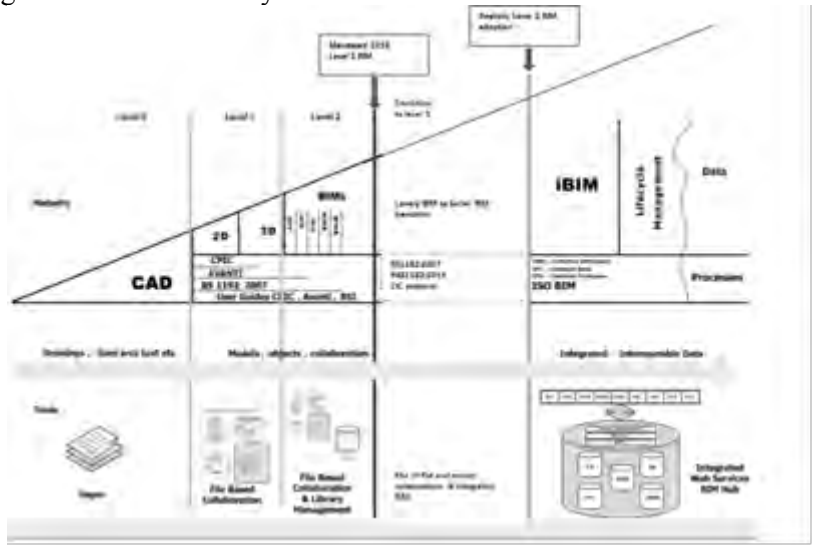

Figure 1. Modified BIM Maturity Index: from Mandated to Realistic BIM Adoption through a Transition Period (After Bew R. 2008)

Some might also argue that a good proportion of the above claims are file sharing through a management system, often set up by the main contractor or the local authority and used by the various professionals, or simply through a simple drop box. One may even argue that most of these repositories are there to comply with BS1192-2007 and at best provide a level of passive data exchange, which may assist coordination.

Achieving Level 2 BIM by the UK government 2016 deadline may not be within the reach of all and real change requires a modification of work practices and cultures. The following modifications are essential for any small business aspiring to enter the digital age and harvest some of its rewards.

It is a recognised fact that in the new digital age there is a conflicting generational skills gap within the construction industry. First, a new younger generation of graduate professionals well trained and versed in ICT tools and working methods has been entering the construction industry professions next to a well-established older generation whose knowledge of these technologies is limited to say the least. And often do not share the same attitudes as far as the potential of these technologies. Second, the managerial power within the industry dominantly resides with the older generation. The latter is often sceptical and reluctant to adopt unfamiliar technologies and working practices in which the risk is perceived to be high. A resolution of this generational gap is critical through a combination of faith in the technologically skilled younger generation combined with an element of business risk; and the recognition that the status quo is not an option in the medium to long term.

There seems to be a resistance amongst SMEs and micro-SMEs in particular to look beyond tools required to do the job. This sense of immediacy, often born out of work environment necessity, needs to give way to an attitude in looking beyond the immediate through continuous planning and investment is the best guarantor for long-term business success.

Embracing BIM technologies within the context of digital Britain is not a series of technical fixes but demands first a belief in this radical change and second the consistent embedding of these new technologies in the business processes and workflows of the whole organisation.

Developing a business model and outlook that recognises the inevitability of change and continuous learning both at the corporate and

individual level are essential. Once a full commitment is made, it could be argued that real transitional change to BIM for an SME may be implemented more efficiently and in a shorter time scale.

The inherent agility of SMEs to adapt to changing business conditions could be deployed to modify work practices and shorten the transition period to level 2 BIM and beyond.

2.2. TAILORING BIM TO SUIT BUSINESS MODELS

Within the UK construction sector, BIM literature (the evangelical model as opposed to the evolutionary one) with all its facets and mantras (collaboration, communication, project efficiency, carbon reduction, whole life asset management etc.) has focused on implementation in large design and construction companies. These organisations operate at a much larger business scale than SMEs and Micros representing the majority interests in the sector. For these large organisations, engaging with BIM may offer competitive advantages, which can be easily afforded, not only to maintain leadership in the market but also to harvest the business benefits BIM may bring to the table. In that context, where does the debate leave the SMEs in the sector? It seems that until recently, this 90% majority stakeholder interest has been left on the margins of the debate. With the cut-off date for the UK Government's mandate imminent, will there be a gradual awakening, realisation and actions in respect of how BIM may impact on UK construction in the round (the evolutionary model). From the sub-groups set up to deliver on the Government's BIM agenda, BIM4SME, has developed as a cross discipline grouping of interests championing BIM and promoting, in particular, the interests of construction sector SMEs. Its primary and only focus is to support the SME community in its understanding and use of BIM, whether they are consultants, contractors, specialists, suppliers or manufacturers.

As BIM paradigms continue to emerge, develop and evolve across construction disciplines, the idea of BIM requiring new business models has become more established and is challenging traditional methods of delivering building projects. Typically, in a traditional model, the overall process consists of two interlocking sub-processes or activity nodes, design/construction activities (process node) and policy and codes (policy

node). Technology is normally embedded within the activities of each node with limited cross over.

Figure 2 illustrates a new BIM business model in which a third technology node interlocks with the other two has become critical to process development. In a BIM working Environment the interlocking area between the three nodes will proportionately increase with the maturity of the BIM system providing more opportunities for collaboration between stakeholders.

The IT infrastructure and expertise required to support a BIM model are sufficiently complex that they need to be run and managed often by external specialist network and data management agencies. A number of these companies are already active in the market including data repositories and providers of web and cloud based construction collaboration technologies. Such a business model could be considered imperative for an organisation in the construction sector to capitalise on the benefits of implementing BIM, (efficient workflow, collaborative working, building partnerships, good communication etc.) and add value to their business.

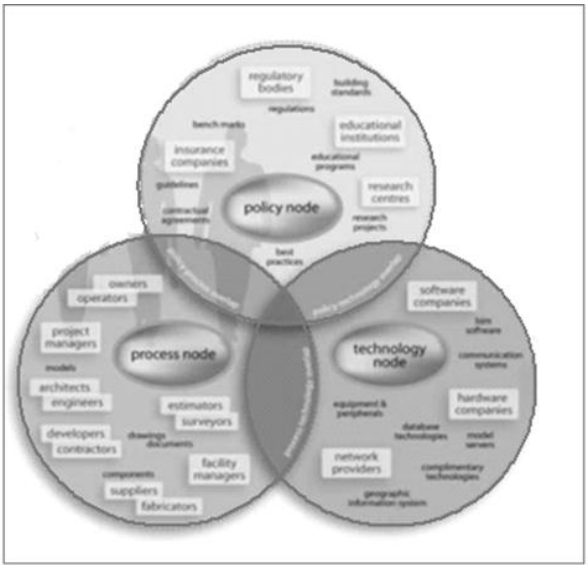

Figure 2. The 3 Interlocking nodes of BIM: in a BIM working Environment the common areas will be much bigger providing increased collaboration opportunities between all stakeholders. (After Razvi S. 2008)

Software as a service provided by technology companies has passed the good idea stage and its uptake by construction industry organisations is on the increase. This method of accessing advanced ICT technologies may help to free design and construction organisations from a burden they neither have expertise in nor is it a core of their business. Additionally, the rapid change in IT software (release of new versions and issues of compatibility amongst others) may make leasing BIM and data management software an attractive proposition that allows organisations to focus on areas of expertise and business growth.

2.3. FILTERING OUT ACHIEVABLE BIM OUTCOMES FROM GENERIC AND BESPOKE ASPECTS OF PRACTICE

"A comprehensive and growing collection of BIM objects spanning all building fabric systems", this is how the NBS describes its National BIM library as an example of generic BIM. Modelling buildings' performance, constructability, health and safety and so forth relies on populating the BIM model early in the design process to facilitate testing, simulations and early problem resolution. This is expected to happen before many consultants have worked the details of their design. Generic objects developed on standard average components are often used early on in the design to be able to run these simulations and test performance. Increasingly manufacturers are supplying the market with their specific component and material parametric objects ready to be used in a BIM model. The use of these objects is common practice in many software packages.

The most important usability feature of the NBS national data base is the quality of data as all objects including contained data need the highest level of accuracy and standards. The generic aspects of BIM, be it a component data base or BIM model viewers contribute to the implementation of BIM and can be an easy access options to SMEs and Micros embarking on a BIM journey.

The number of technology companies already active or entering the market is increasing. These companies provide bespoke technological solutions ranging from complete BIM solutions to very specialist service applications. Clash detection, specialist project document management systems are typical bespoke solutions. For instance BIMsync, currently in

Beta format from BIM technologies, is an automated specification tool allowing for 2-way syncing between specification and model production of a validated approved specification. An innovative application that is exploiting a developing niche BIM market bridging the gap between a BIM model, specification and approved validation of specification. At the other end of the spectrum, Solibri is a bespoke Model Checker software with wide capabilities. It performs advanced clash detection, deficiency detection, BIM and accessibility compliance, model comparisons etc. at the higher end of BIM workflow.

Navigating generic and bespoke aspects of BIM is an exercise every built environment organisation will have to go through as part of an analysis of their business model and the separation between discipline specific and cross-discipline activities. The analysis exercise would help frame business and workflow priorities and identify aspects of BIM principles and tools relevant to the business model.

3. Tools for effective collaborative working

3.1 SETTING UP AND MANAGING TEAMS ENGAGING WITH BIM

"During the time of the renaissance, architects like Brunelleschi were afforded the opportunity to operate as a master-builder. This paradigm allowed one person to hold complete knowledge of both the design and construction methodologies implemented in the building process, partially due to the relative simplicity of the building system at the time. Integration, so to speak, was automatic." (Krygiel and Nies 2008)

The role of the master-builder split, after the Renaissance, into architect/designer and contractor roles, one became responsible for the design of the building and the other for its construction. At this point coordination and team collaboration became necessary to achieve the expected building outcomes. Ever since, technologies continued to evolve and the design and construction of building became increasingly complex. As a consequence, building systems needed greater specialisations which lead to the growth of numerous built environment professions (architects / designers, engineers, surveyors, project managers...). This led to the

compartmentalisation and fragmentation of the construction industry which in turn lead to a silo mentality.

The complexity of construction projects and related processes requires the input of a design and construction multi-disciplinary team to deliver project outcomes. The Royal Institute of British Architects (RIBA) "Plan of Work" recognised the importance of collaborative teamworking in design and construction since the early 1960's. It recommends the setting up of a design team early in the design process (Stages 0&1). However, members of a design team represent different disciplines that are often fragmented and at times adversarial as indicated in the 1994 Latham report. With the different disciplines come different ways of working, thinking and talking about design. The different disciplines also become involved at different stages of the design process. Despite the above, the design-construct team is expected to deal with the multiple layers involved in today's complex design layout, structure, project data, cooling, ventilation, heating, security, plumbing, lighting etc. Figure 3 summarises these complexities each of which requires expertise to deal a host of issues.

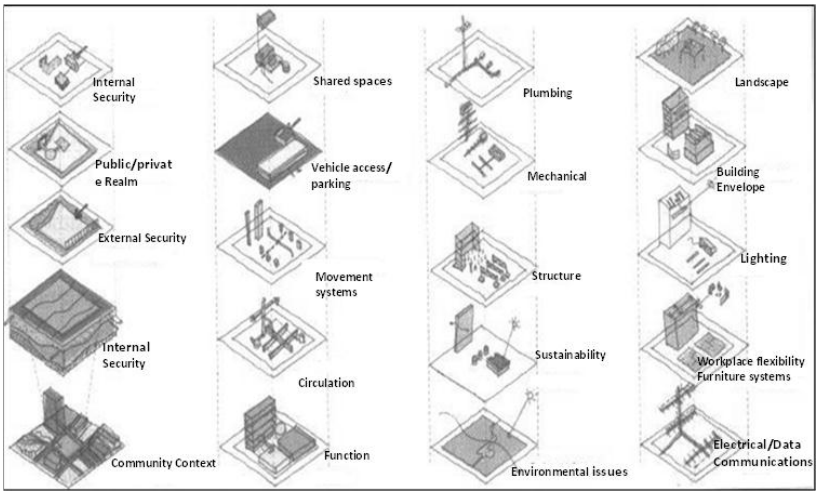

Figure 3. Layers of Design (after Krygiel and Nies 2008)

Multidisciplinary team collaborative working is not new in the construction industry but it can be argued that its extent has until recently

been limited to the minimum required by a project, often to resolve problems. The introduction and increasing implementation of BIM technology in the industry in recent years has significantly redefined design and construction team interactions and refocused the collaborative processes involved. Central to this redefinition is a shift of focus from team members' roles and the contributions they make to the product itself i.e. the building throughout its whole lifecycle. This does not fundamentally alter the nature of team members' input but creates a collaborative working environment that fosters early involvement, transparent information exchange and reliable data process management and control as illustrated in Figure 4. As a result, the logistics of involving all stakeholders is made simpler and easily manageable through a BIM workflow.

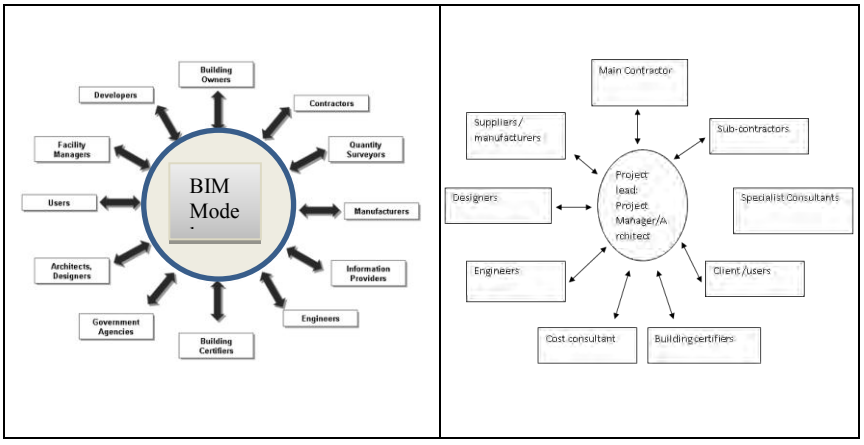

Figure 4. Team collaboration using BIM & traditional methods

Exploiting the collaborative capabilities of BIM constitutes a cornerstone of the Government construction task group Push – Pull strategy which revolves around two key criteria, whole life cost, including savings in capital cost, and carbon performance together with related processes. Within the Push element, BIM is seen as an enabler to timely and accurate information delivery, as well as to effective and transparent decision making. This strategy renders the collaborative use of BIM by multidisciplinary teams, as opposed to BIM technical aspects, essential to a

built environment practice or company of any size within the overall supply chain. At the same time the IT tools, the technical aspects, supporting any BIM system are essential to the processes of design and construction team collaboration and management.

Despite the evolving design-construct team working processes and the new collaborative tools being deployed to meet BIM level 2 goals and beyond, a fundamental question still remains to be fully answered, namely who will lead and most critically pay for the overheads related to the setup and management of teams and associated systems? The anecdotal consensus in industry points to the client, being the main beneficiary of the final outcome both in terms of the facility being delivered efficiently and inheriting the model for lifecycle use. In practice, however, the picture is not at all clear; large design and construction organisations tend to absorb the costs for a combination of reasons that include, amongst others, market leadership, internal process efficiencies and self-promotion. The situation amongst SMEs and particularly micros remains ambiguous with isolated initiative. An early consensus on design-construct team leadership together with associated remunerations would help expedite BIM implementation as well as harvest its benefits.

3.2 LONELY BIM AND COLLABORATIVE WORKING

It would not be farfetched to assume that the overwhelming majority of built environment organisations are currently using a combination of IT tools in their day to day technical and administrative business processes. The use of these tools can vary significantly ranging from basic 2D CAD drawings to advanced 3D and BIM models. The construction industry is still heavily reliant on the use of 2D drawings both paper and digital in information production and operations stages. Furthermore, the increasing use of parametric software platforms capable of producing data rich design and construction information together with the rapid development in ICT technologies such as the internet have brought about new working opportunities and changes to working practices unimaginable two decades ago. Implementing BIM working practices is still evolving as part of an inevitable transition period, which has given rise to a spectrum of paradigms ranging from lonely BIM to collaborative BIM.

Lonely BIM is a term used to describe the practices of an organisation, project team or the whole market where the generated BIM models are not exchanged between project team members. Also organisations at early stages of BIM implementation or who only generate mono-discipline models are considered to be practicing Lonely BIM, a position between level one and two on the BIM maturity index (Figure 1). Practicing this level of BIM can bring internal efficiency gains, build capability and develop BIM processes, a respectable position for an SME or micro organisation aspiring for the next stage, level 2. The biggest prize for a lonely BIM practice, one would argue, is twofold; one is making the major paradigm shift from conventional building representation using 2D drawing devoid of any information to creating virtual models not only embedding valuable information related to performance, specifications etc. And two establishing BIM workflows and processes that help bring efficiencies and prepare for the next level of BIM.

Collaborative BIM is a term used to describe the practices of an organisation, project team or the whole market where multi-discipline models / BIM-models are generated or are collaboratively exchanged between Project Participants. Collaborative BIM may also refer to elevated BIM Maturity within a market. That is the mature level 2 on the BIM maturity index. This level of collaborative BIM is at present the privilege of a small minority of large organisations and remains aspirational for the majority of SMEs and micros in the UK constructions industry. The benefits of collaborative BIM are well established in the literature, but the greatest value to a built environment practice is to endeavour to exploit the full potential of collaborative BIM beyond the statuary or contractual requirements of a project. Building partnerships and linked networks with suppliers, manufacturers, specialist consultants etc. to foster long term collaboration are typical examples.

4 Whole life view with BIM

4.1 DEVELOPING AND APPLYING BIM STRATEGIES TO MEET CLIENT AND USER EXPECTATIONS

The 2013 RIBA Plan of Work introduced the strategic definition stage (stage 0) which focuses on identifying the client's business case and Strategic Brief and other core requirements for a project. On the other hand, Graham Jones, chair of BIM Steering Group Europe, identifies three conditions for success when building a strategy for BIM at the early strategic stages of a project, and he baptised them the why, what and how? For any project using BIM a strategy needs to be developed /customised to meet the requirements and arrangements of that particular project. Borrowing Graham Jones terminology, the following will explore the key strategic developments that need to be considered.

WHY in the strategy includes a definition of purpose and conducting an appraisal in which targets and objectives are identified and mapped, and a robust business case for the project is well argued. In parallel, a BIM strategy should be developed as part of this overall strategy and fed into the subsequent preparation and brief stage in order to meet the overall client and user short and long-term expectations. Key strategic points to be addressed early include:

- Specific (lifecycle) information required from the supply chain
- Uptake and adoption of BIM to facilitate compliance with 2016 mandate
- Consistent handover of digital data in the appropriate format (IFC, COBie) and at the appropriate time
- Specification of the required functionality (3D to ND and FM)
- IT platforms and compatibility issues to facilitate information flow and handover
- Client participation and interaction throughout the process.

WHAT focuses on the comprehensive definition and project deliverables, any relevant precedent experiences and/or examples. Specific definitions of project deliverables will assist in determining accurately the appropriate BIM strategies to be deployed to meet client and project targets; these may vary from the functionalities of CDE, specialist tools or expertise required. In BIM one size does not fit all, each project / client invariably will need a customised solution on a need basis. Size of project,

complexity of design and construction expertise of design-construct team members are only examples of variables that may impact on the customisation. A review of previously deployed processes or similar projects undertaken in which tested methods together with any lessons learned could be adapted or re-used. In accordance with the project structure

Deployment and implementation, the HOW, is the critical component of any BIM strategy. Regardless of the clarity of purpose and definition of project objectives, if the processes put in place are not well executed client and user expectations will not be fully met. Prior to implementation the following guidelines should be carefully considered.

- Clarify the overall management structure of the project and how the BIM process fits in including the definition of roles and responsibilities of all stakeholders
- Identify any risks likely to rise throughout the process and put contingencies in place
- Identify the expertise required, both internal and external, and consider team members suitability and dynamics
- Define workflows in relation to project procurement and contractual arrangements
- Be clear of the project programme, targets and how they are to be met
- Specify collaborative and communication protocols including data exchange timetable
- Define milestones to deliver and meet project and client expectations
- Define protocols and processes both internal and external.

Developing and implementing BIM strategies need careful planning and synchronisation with the overall project programme and client and user expectations. In addition, any strategy needs to be designed within the context of the BIM maturity level of the design-construct team.

4.2 SETTING AND REALISING WHOLE LIFE TARGETS FOR DESIGN, CONSTRUCTION AND USE

One of the major developments in the procurements of buildings and infrastructure in recent years has been breaking the barrier that until recently existed between design, construction and operation. The

introduction of BIM processes accelerated the integration of design and construction stages, which was then followed by recognition by clients and other stakeholders of the value of integrating the operation stage in the overall asset cycle. Government soft landings standards added greater impetus to the early planning of whole lifecycle as well as asset handover. Looking forward towards an increasingly integrated process of delivery and asset management post construction, setting and realising whole life targets for each of the above stages becomes critical for both the success of the project and in meeting clients and users expectations. BIM as a process is a key enabler in meeting these three stages targets by providing the opportunity for radical improvements in building design, construction and operation through advanced computer-based modelling and data management technologies. At design stage, targets may include setting standards for carbon footprint, design quality, overall environmental impact, collaboration and coordination, project data and information flow, communication protocols and so forth. To help realise these targets in an efficient and cost effective way, a BIM system needs to embed these outcomes as part of its processes and protocols. This way all members of the team are systematically aware and focused on meeting these built in targets using the appropriate tools and processes of the BIM system. For instance, specifying a target carbon footprint per square metre in an environmental analysis tool (integrated or as a plugin) will automatically throw a fail result until the target value is met.

Interface between design and construction is a good illustration where the deployment of BIM could have a major impact on a project's quality, cost, time and associated risks. A visualisation of construction sequence or assembly of prefabricated components using manufacturer 3D objects or pre-construction site layout including scheduled deployment of plants are effective virtual methods of identifying and eliminating risks. Clash detection for design / construction coordination is a function of BIM that has proved critical in identifying and eliminating constructability problems traditionally only identified during construction often with an impact on delivery time. Using an integrated BIM model, any constructability issues identified late can be rapidly resolved given the instant access to the relevant project information. In addition, flexibility of re-scheduling, re-costing and even re-sequencing of building operations will aid in realising targets.

"Hindsight before site", that is the ability to prototype the asset lifecycle (Jones 2011) at the early planning stage. A BIM model provides early access to useful information that will help a better understanding of the asset, which may be used in a number of ways to meet targets. These may include sales and marketing for a developer, future maintenance / refurbishments cost modelling or security and surveillance. It is important to keep in mind that the reliability of BIM as an enabler to realising targets throughout the whole life cycle of an asset is dependent first on the clarity of overall project objectives and second on the level of maturity as these will impact on the quality of outcomes which in turn may help or hinder realising the full potential in meeting targets.

4.3 ENGAGING CLIENTS AND BUILDING USERS THROUGH SIMULATION AND PROTOTYPING

At the early design stage of a building, when ideas are still very fluid and very little concrete design material is available, has always posed difficulties in how to engage clients; particularly when critical decisions need to be made to advance the design process. Beyond technical drawings, architects and engineers historically relied on simple 3D drawings such perspectives, sketches etc. and scaled physical models to communicate design intent and aesthetics. These techniques were developed further with the introduction of CAD but the principle uses remained largely the same. The introduction of 3D modelling followed by parametric modelling and the ongoing digitisation of the construction industry has provided new and innovative methods of communication to designers and clients, which were the preserve of other industries. Simulations and prototyping are increasingly replacing older techniques as they are more versatile, command accuracy, communicate better information and are a by-product of the new digital design process.

Simulations are the most versatile and easy to produce from a BIM model at any stage of the design process. An early model may not contain lots of data but is sufficient to engage with a client in relation to issues relating to siting, urban or rural landscape integration, aesthetics, quality of internal space, planning etc. Merging visualisations with existing GIS or Google Earth city models, for instance, will provide informative and contextual simulations which clients can easy understand and relate to, and

eventually help making decision quickly. In the same vein, an advanced model may be used to simulate a client fly through to ascertain the quality of space, internal finishes and also provide an interactive capability for the client to change and modify aspects of design from colour schemes to fittings and materials. Not only decisions are almost made instantly and fed back into a model, the active engagement of clients and users enhances their experience and increases success rate in meeting their expectations as well as project targets.

Taking a step further from the traditional physical model, a prototype helps to engage clients in visual and tactile ways. It is the nature of people to see and touch objects to appreciate their qualities and functionalities. In a BIM process, data for making a prototype is built in the 3D model and little effort is normally required for making a prototype (file formatting and machine set setup). Whether in building or product design, a prototype is used to describe a product more effectively, test the performance of various materials and components, engage clients / potential clients either for feedback or marketing as well as test and refine functionality. Their use in building design and construction is wide and may range from a scaled prototype of a whole or part of a building to a detail of a component or assembly or to a particular space. For instance a scaled prototype of a standard hotel or hospital room will help a client to engage in the accurate and meticulous details of internal fittings and finishes, equipment, services installations and so on. Further iterations of the prototype can be made quickly once feedback and any redesign has been completed in the 3D model.

SMEs and micros can exploit the use of these digital techniques when interacting with their clients regardless of how advanced their BIM implementation level. One might argue that the agility of a small practice in adopting innovative technologies can assist in improving customer service, expand business opportunities at minimal overheads, especially when using visualisations.

4.4 EMBEDDING SOFT LANDINGS PRINCIPLES INTO PROJECT PLANNING AND DEVELOPMENT

Soft Landings is the BSRIA-led process designed to assist the construction industry and its clients deliver better buildings. It is also intended to help

solve the performance gap between design intentions and operational outcomes. Embedding soft landings principles into project planning and development occur at various stages of the project cycle with the overall intention of safeguarding quality and easing the handover to clients and facilities managers.

At inception and briefing stages, specific activities related to soft landings need to be added to client's requirements, developed as part of the project brief and also included in any tender documentation so that budgets are set aside for post-handover care and post-occupancy evaluation. This enshrines these specific activities in the contractual arrangements of the project and makes them mandatory for all relevant stakeholders. Depending on the scope and complexity of the project, specialist consultants or sub-contractors may be required to inform on the nature and extent of activities to be included, which will also help in identifying skills and resources required. BIM protocols for data drops handover or transfer of project data onto the client's Computer Aided Facilities Management (CAFM) system are some of the principle activities to be embedded at this early stage.

During design and development stages, precedents should be considered by all project team members to gain insights into tried and tested solutions and explore how the future building will be used by end users and facilities managers. Strategies or future activities identified and agreed should be embedded into each team member relevant design which later will be incorporated in the BIM model as appropriate. Some of the principles and related activities to be agreed and embedded at the stages include the energy strategy and targets, in use energy monitoring regime, commissioning strategy and timetable, usability and maintainability of installations. These principles need to be reviewed and updated as the design develops for feasibility and buildability purposes.

A phased handover of the completed building should be planned and embedded in the overall soft landings strategy. This will mostly impact contractors and sub-contractors schedules which should be managed and updated in accordance with the handover strategy. A phased handover avoids overwhelming, particularly in complex projects, operators and FM managers and enables them to spend more time understanding interfaces and systems before occupation. Activities to plan for may include the practicalities of project data handover, BMS setup to initial client requirements, energy monitoring software and any initial training on

management or monitoring software. BIM data from design-construct team need to be as built updated, checked, and handed over in the specified format.

Post-handover, a period of six to eight weeks is recommended to be scheduled by project team members during which they need to deal with any emerging issues related to system operations, software malfunctions etc. It is also critical at this stage that all aspects and systems of the building are checked against client's soft landings requirements and meet their expectations. Long term POE should also be embedded and may include activities related to long term energy performance, reliability of installed software systems, and any discrepancies on project data. As recommended by Soft landings guidelines, systematic post-occupancy evaluation are to be conducted no sooner than 12 months post-handover, then repeated at 12 month intervals and culminating in a final project review at month 36.

5 The value of I in BIM

5.1 THE VALUE OF ACHIEVING SMOOTH INFORMATION FLOW IN MEETING OBJECTIVES

Delivering constructions projects to meet the triangle of quality, cost, time and to the satisfaction of project objectives is the flow of information through the various design and construction stages of a project. Built environment projects involve huge volumes of information that have to be transferred between numerous different project stakeholders throughout the building life cycle. Further, much of that information is graphical in format. Over the years, built environment professionals have evolved ways of managing that volume of information by employing various tools and techniques such that the client brief remains valid in a fast changing industry landscape peppered with new working practices, new technologies, evolving contractual and legislative frameworks amongst others. However, being able to identify the current information you require, retrieve it and manage its flow efficiently is still far from easy on most projects. The complexity of construction project, the associated large quantities of data to be processed and the ever-increasing statutory and

technical requirement render the smooth flow and management of project information a key component to successfully meeting objectives.

As illustrated in Figure 5, traditional information flow is fundamentally linear and follows a phased sequence of design and construction activities predominantly based on the RIBA plan of work model. Project information tends to be contained within each phase, such as design or procurement, until such a time where it flows to the next phase and remains largely invisible to other design-construct team members; particularly members with minor contributions such as a small ME subcontractor.

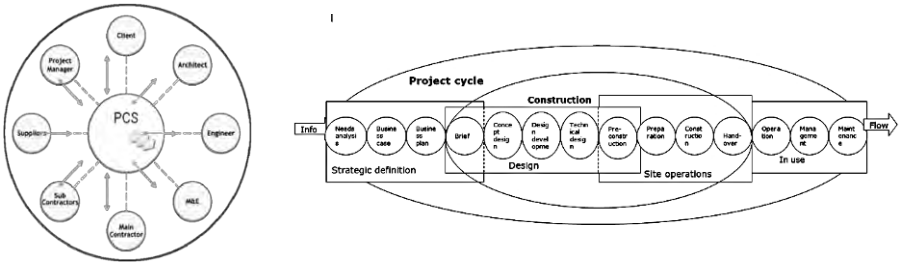

Figure 5. BIM and Traditional information flows

Collaboration is very limited by virtue of the phased nature of the flow and incompleteness of information between phases. In a collaborative BIM working environment, however, the flow of information is continuous, up to date and access to all stakeholders is automatic within project protocols. The bidirectional flow between each contributing member and the model (single or federated) simplifies the flow process and adds transparency. Simultaneous working and live interactions of team members via a BIM model in a Common Design Environment enables the highest levels of collaboration and smooth data exchange.

The value of smooth information flow and the collaboration potential it generates resides not only in delivering project objectives but also in creating long term working relationships / partnerships and meeting wider and global goals such as CO2 reduction.

5.2 INTEGRATING WORKFLOWS TO REALISE WHOLE LIFE TARGETS AND OUTCOMES

The recent shift to using parametric modelling software and associated BIM workflows has been a game changer in the way project information is shared and accessed in a collaborative working environment. Smooth workflows are essential to collaboration and any barriers will not only hamper team working but also limit the benefits that may be derived from that collaboration. Realising whole life targets and outcomes of an asset requires careful integration of these workflows throughout all stages and processes from inception to decommissioning.

A number of issues that may affect the integration of workflows are explored here. Interoperability of project data across platforms, that is the ability to access and utilise BIM data model files authored by different software platforms, was until few years ago an obstacle for a variety of reasons ranging from purely commercial to technical. The International Foundation Classes (IFC) format is increasingly becoming the accepted standard for open BIM allowing for full interoperability between BIM authoring platforms. Wider adoption of open standards by the range of software platforms used in the construction industry is vital for smooth workflows and critical to the success of the Government's strategy for BIM adoption. Linked to data standards in the government BIM strategy is the quality and reliability of asset data to be made available to clients, known as data drops in a COBie standard. A complete COBie should be expected by clients at the time of handover, but earlier interim drops at key stages of the delivery cycle are used to monitor the business case for the facility and to help plan for taking ownership. Once received by the client, the COBie information can either be kept as delivered, or held in ordinary databases, or it can be loaded into existing Facility Management and Operations applications, either automatically or using simple copy-and-pasting. (COBie 2012) This full asset data handover marks the start of the facility management cycle of the workflow. Also essential to the integration of workflows is for the design-construct team to agree, as early as feasibly possible, all protocols and standards. These will include, amongst others, those related to information management, data exchange, data format standard etc. CIC protocol and the mandated information manager role will,

when fully applied, assist in the integration of workflows and the overall management of project information in a collaborative BIM environment.

In summary, each building asset will be expected to realise well defined targets and outcomes at different stages of the lifecycle and to different stakeholders. Adopting, early on in the process, an integrated approach to the setup, implementation and management of workflows will assist in meeting the set targets and outcomes.

6 Conclusions

This paper set out to first explore in practical terms the challenges, risks and benefits a SME may face or derive from the implementation of level 2 BIM; second to identify key points for a toolkit strategy to facilitate this implementation.

The challenges facing an SME or Micros are not uncommon in the industry such as investment in hardware/software, training, change of attitudes etc., but these challenges are magnified many folds given the competitive nature of the BE professions and the small profit margins. Add to that the technology age gap between young technologically savvy entrants to the profession and older generation unfamiliar with new technologies and highly risk averse. Most SME consider implementing BIM quickly as a very risky venture and if not getting right could mean financial ruin and failure of the business. Getting right means greater opportunities that may range from new markets to innovative and technologically advanced processes and business practice.

A key point of the toolkit strategy is to review the business model to include technology innovations, new processes and developing legislative framework. This means a) applying need to know principles for thinking and doing and b) tailoring BIM to the MSE's developing business model by filtering out achievable BIM outcomes from generic and bespoke aspects of practice and in relation to organisational size and resources.

Another key point is building and managing teams that are capable of exploiting the collaborative potential of BIM and engaging collaboratively internally and externally through a project lifecycle. This extends to change of working practices, workflows, adopting new management processes and

associated new technologies to engage with clients / users and all stake holders.

The point above also means having a whole life view with BIM. Evidence from pioneering SMEs suggests that this can only be achieved by an objective assessment of team capabilities, skills, processes and protocols. Defining and evaluating these indicators objectively will minimise the risk of implementation and increase confidence and success.

Key to the whole BIM strategy is Information. A quick transition from a linear to a collaborative smooth flow of information has proven to be critical to meeting objectives. Adopting an integrated workflow through a common data Environment (CDE) is an essential component early on in the implementation process. A managed transition from lonely to collaborative BIM seems to be a logical step in any strategy as part of the evolutionary BIM paradigm. Combined with the adoption of new protocols and standards data management processes (CIC protocol, IFC format, COBie…), the road to level 2 BIM implementation has in limited case studies proven less bumpy that anticipated.

References

NATIONAL FEDERATION OF BUILDERS, (2012) BIM: Ready or Not? [online] Available at: http://www.builders.org.uk/resources/nfb/000/318/333/NFB_BIM_Survey_BIM-ready_or_not.pdf [accessed 26.02.2015]

MAYNE T., (2005) the Building Information Modelling Panel Discussion, at the 2005 AIA national convention, Las Vegas

MACKAY F., (2013). Building Information Modelling: Legal Implications of BIM; Are Fife and Tayside Practices Ready for The Implementation of BIM? Unpublished architectural technology undergraduate dissertation, School of Contemporary Sciences, University of Abertay, Dundee.

BIM4SME, (2015) [online] Available at: http://www.bim4sme.org/about/the-organisation/ [accessed 12.02.2015]

Razvi S., (2008) BIM and the Process Improvement Movement, Building a case for a combined BIM–CMMI Framework, [online] Available at: http://changeagents.blogs.com/thinkspace/files/BIM_ThinkSpace_The_Process_Improvement_Movement_by_Sohail_Razvi.pdf [accessed 12.02.2015]

BIM Technologies., [online] Available at: http://www.bimtechnologies.co.uk/ [accessed 12.02.2015]

Solibri Model Checker., [online] Available at: http://www.solibri.com/ [accessed 12.02.2015]

BIM Excellence., (2015) [online] Available at: http://www.bimexcellence.net/ [accessed 26.03.2015]

KRYGIEL E. AND NIES B., (2008) Green BIM, Successful Sustainable Design with Building Information Modelling, Wiley, pp55.

HM Government., (2013) Government Construction Strategy, Her Majesty's Government, London [online] Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/61152/Government-Construction-Strategy_0.pdf

LATHAM M., (1994) Constructing the team - The Latham report, Department of the Environment DOE, London, UK.

GARRETT G., (2008) "Heathrow Terminal 5" [online] Available at: http://aecmag.com/case-studies-mainmenu-37/253-heathrow-terminal-5 [accessed 26.03.2015]

RIBA Plan of Work., (2013) [online] Available at: http://www.architecture.com/files/ribaprofessionalservices/practice/ribaplanofwork2013overview.pdf [accessed 15.04.2015]

JONES G., (2011) Building a Strategy for BIM, [online] Available at: http://cic.org.uk/admin/resources/dl-cic-bim.pdf [accessed 14.04.2015]

BSRIA, Soft Landings, [online] Available at: https://www.bsria.co.uk/services/design/soft-landings/free-guidance/ [accessed 15.04.2015]

CIC., (2013) Building Information Model (BIM) Protocol, [online] Available at: http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCIQFjAA&url=http%3A%2F%2Fcic.org.uk%2Fdownload.php%3Ff%3Dthe-bim-protocol.pdf&ei=8AIbVYf-K8TFPdLIgYgI&usg=AFQjCNFidb5EChOC47YSpT_4yWExy7hocQ&sig2=HoVhma_VieT_SRhhlzSEsg&bvm=bv.89744112,d.ZWU [accessed 31.03.2015]

CIC., (2013a) [online] Available at: http://www.bimtaskgroup.org/wp-content/uploads/2013/02/Outline-Scope-of-Services-for-the-Role-of-Information-Managment.pdf [accessed 31.03.2015]

COBie., (2012) [online] Available at: http://www.bimtaskgroup.org/ [accessed 31.03.201