Digital Masterbuilders: Modernising Communication between Designers and Constructors

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Abstract

BIM is revolutionising the way we design buildings and share design data, but most construction workersôsite duties remain unchanged. In an increasingly BIM-centric industry - with 3D collaborative models and post-occupancy analysis ï it is clear that the site based pen and photocopy remain a stumbling block to collaboration. The impact is evidenced in the Performance Gap and the consistency with which projects run over budget and programme. This paper will review how technical co-ordination and realisation stands to benefit from a rethink of communication. This paper will introduce ACCEPT - a multi-national research project funded by H2020, as a prospective means to improve knowledge transfer and quality assurance on site through the use of digital technologies such a tablets and smart glasses.

Keywords BIM, performance gap, ACCEPT, collaboration

1.0 Introduction

The construction landscape is changing rapidly; partly due to our hesitant emergence from the longest recession in living memory but also, in no small part, as a result of the fast approaching target date of April 2016 for the adoption of BIM Level 2 on all UK Government procured projects. The understanding and uptake of BIM as a holistic methodology is however still patchy across the industry despite 92% saying they will be using BIM within the next 3 years **(1)**. One of the clearest disconnects is between the design team - working in a shared data environment - and the construction site operatives; using red pens, paper and photocopiers.

Real-time collaboration between the design team and construction worker is limited due to constraints in time, location and will, and reinforced by contractual and PI arrangements that encourage silo thought patterns and discourage cooperation.

Historically, such a rustic approach to collaboration went unquestioned because it was in keeping with the methodologies and timescales of engagement used through design development and occupancy; many remember receiving RFIs by fax and filling in the response on a weekly basis on the way to site. The common expectation now is that emails should be responded to within 24 hours (at most), and yet this weakest link means that most buildings are not being built any faster or with any greater degree of accuracy.

True engagement must be a two way process. The designers must be able to transmit information quickly and accurately to site, but assuming an accurate, full design has been completed - it is perhaps more important that the construction team

can transmit queries and information requests swiftly back to the design team.

2.0 Research

2.1 Clients

The challenges of BIM start in procurement. Clients need to be driving the process and it is worth noting that the earliest data exchanges need to come from the client team in the form of Employerôs Information Requirements.

Notwithstanding, clients are getting enthusiastic; even in 2013 over 50% of clients expected their consultants to have BIM as a core competency (2). As noted by Dave Monswhite (Assoc. Director, BIM) in his 2014 Insight report for Turner and Townsend clients potentially have a huge amount of information within a BIM model and can use it to make powerful decisions: ñ*Clients looking to extract maximum value from their investments should ensure they are using credible information to inform their decision-making – today and in future*ò(3).

The more digitally mature clients now understand the value of BIM whether for control of Health and Safety, control of the building envelope or early simulation of eventual building performance. However many clients are currently asking for BIM even if they donôt really know what it is; trying to buy the same list of design services that they have always bought. Clients need to understand and realise that in a BIM governed world they need to make more, earlier decisions, but most organisations are not set up to do this. If they donôt procure the right process in the first place, and donôt constantly make sure they are understanding the model and getting what they want, then the end product is unlikely to meet all of their requirements.

There is a growing realisation that BIM really is all about communication and collaboration which really only comes once clients start to procure BIM projects and discover the potential pitfalls for themselves. Similarly, the receipt at the end of a project of a sparsely populated Facilities Management model is a great demonstration of the importance of early and accurate information input.

2.2 Designers

Uptake of BIM during design has been steady and increasing, with 68% of design consultants now producing 3D Digital models, of which nearly 80% are used in a collaborative environment (1). The report also notes that ñ*BIM adoption is moving from being led by innovators and early adopters towards being a more mature market, where the more mainstream are investigating and assessing the benefits of doing so".*

Teaching in architecture and engineering is shifting rapidly, with new graduates joining the industry equipped for this new way of working. There is a growing recognition that alongside technical training, BIM requires a cultural change towards truly collaborative working. The Innovate UK funded Meadow Road housing scheme is testing out this process of change and Julian Bullen, project director, notes that ñ*The biggest challenge is not the tools and processes, but the people. Individuals*

*need to have a level of trust and confidence in one another to work collaboratively using BIM as well as embrace technological change. You have to work very hard to win people over to the concept of change being a good thing, neuroscience shows us that brains are pre-wired to go into flight, fight or freeze mode when confronted by things they are not familiar with.*ò(4)

Collaboration between members of the design team is hugely facilitated by BIM. Hannah George notes that ñIf it's achieved nothing else, it makes pipes, ducts and steelwork attractive and accessible. It's quite apparent that a 3D model communicates the end result like no single line diagram ever could. That alone is a great benefit to the engineer, their client and the team. ò(5).

The cost manager also becomes less of a perceived interference who produces a cost plan at the end of a design stage, forcing time consuming redesign, and much more a part of the team. Cost information can be provided almost continually and expensive mistakes can be avoided.

Architects and engineers are seeing the benefits of coordinating designs in 3D whilst clients are seeing a world of FM with accurate and accessible as-built data. The gap in the middle seems to be the construction professional on site, seemingly working perfectly well with photocopies and red pens.

2.3 Contractors

There is currently a huge variation in BIM ability across contractors, with small and medium sized firms worryingly far behind, and sub-contractors worse off than their main contractor counterparts. This is backed up by a recent study from the Electrical ContractorsôAssociation and its sector partners, which found that just one in six building services firms (16 percent) say they are currently ófully readyôto use BIM (6). Brent Rees of Ridge and Partners hit the nail on the head when he said ñ*We have seen limitations when the main contractor's supply chain hasn't been tested for BIM literacy or capability and has therefore been unable to feed into the process later on"* (7).

Contractors were surveyed anonymously to understand whether there is similar enthusiasm on the building site. According to research, 64% of contractors ñ*have never worked on projects utilising either 3D drawings, clash detection tools, schedule integrations tools or other BIM features*ò(8). This finding is supported by recent industry surveys which suggest that the extent of digital uptake by the typical constructor tends to be limited to programme and costing software and 2D drawing files.

Martin Chambers, director of Shaylor Group is quoted as saying ñWe are not yet getting the full benefits in the construction phase ï as with all change it takes time to filter through. We will only really see the benefits once the site is digitised ï when it is the norm for foremen to carry tablets. Weôve crossed one hump by getting the designers on board and are also beginning to see BIM being used in refurbishment. But the real hard work is getting the benefits on siteò (9)

Interviews with site managers have highlighted a clear status quo within the industry, wherein by far the majority use face-to-face meetings, mobile phones and noticeboards to communicate with others on site. Similarly, contractors

overwhelmingly use mobile phones and emails to communicate with their design team off site, referencing hardcopy design information most of the time. This scenario is almost unanimous amongst sub-contractors too, with 92% stating use of hard copy drawings as their primary means for accessing design information on site. (8)

Whilst nearly all contractors interviewed were confident that their hardcopy drawing information on site would represent the current design information for the building, these contractors were equally as assured that the ócurrentôdesign information was not going to be entirely correct, in that it was not completely representative of the actual site scenario. And therein lies the rub.

The expectations of all parties are low and trust is weak. The success of BIM relies heavily on a collaborative atmosphere in which information is exchanged freely and without concern of retribution. Existing insurance provisions are currently being used on BIM projects and this leads to a ñthem and usòsituation, with design team and contractors all keen to deflect blame. This may be manageable for BIM level 2, but as we progress towards level 3 it is likely this will have to change, perhaps towards a project based PI scenario.

Gaining of trust can only be achieved through better communication. This might be organisational and cultural, with architects needing to ñtrustòcontractors more (and vice versa), or it could be technical, with site operatives needing proper mobile devices on site with high levels of functionality and a strong emphasis on training.

2.4 Why Does This Matter

The misalignment in digital communication uptake between designers and constructors is clearly profound and must surely be a key contributor to the Performance Gap and the consistency with which projects run over budget and programme. Figure 1 below highlights the critical stage of information exchange within a project utilising BIM. Whilst the majority of design decisions have been made, there will invariably be some changes or additional information required as a result of construction works. As such, this critical stage can vary in scale significantly, depending on the complexity of the project, thereby adding more weight to the impact of misalignment in digital communication.

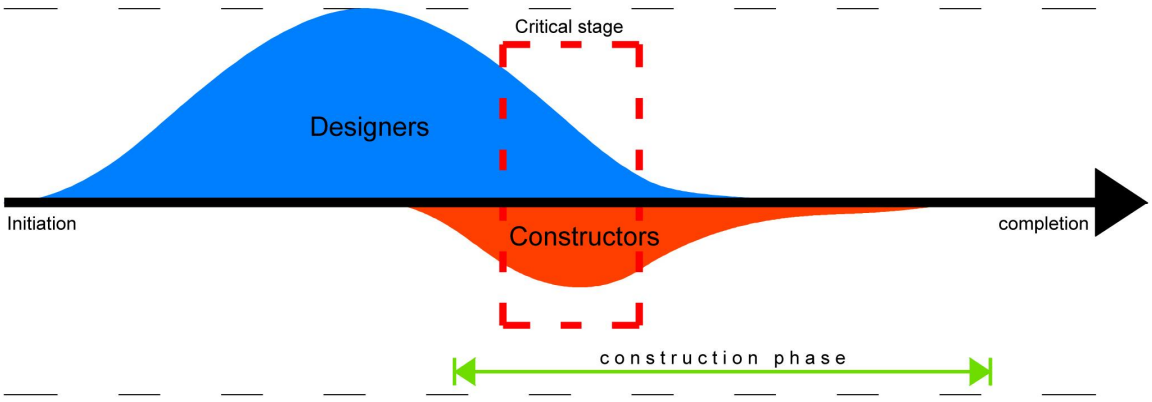

Figure 1: Typical BIM Project Design Resolution

Indeed, every contractor interviewed in the sample group agreed that they are likely to have questions for design consultants about the details provided in the ócurrentô design information, and were in broad agreement that such queries would have an impact on their project programme. (8) The basis for this concurrent response is that whilst most constructors use site-visits as one of their three primary mechanisms for communication with design consultants, the majority disagreed with the suggestion that design consultants can be relied upon to visit site when necessary.

If, therefore, a design consultant does not attend site to review a design query when preferable to the contractor, there is a reasonable possibility that the query cannot be adequately resolved via the remaining preferred communication methods i.e. telephone or email. The query may be too complex, focussed around extremely visual attributes such as glare or material matching, or simply relate to various aspects of the construction which cannot be concisely described via telephone or email. The result is the same; constructors either accept delay, or push on with the risk of quality problems or potential abortive work.

Nonetheless, these affirmations should not necessarily infer most of the blame on the design consultants where programme slippage has arisen from their non-attendance ï after all, the design consultants are likely to be equally short-of-time and may consider their 3D design information to be an accurate reflection of all the site information available to them (they may also have been to site earlier that week). The importance, then, that constructors place upon face-to-face site visits is perhaps far more suggestive of their reliance on traditional communication methods ï and associated defiance in adopting new technologies to support improved communication and workflow.

A few leading contractors such as BAM embrace the change and have adopted a market leading ówhole life BIMôapproach, which spans the entire asset lifecycle (design, construction and operations). At First Direct Arena in Leeds, BAM claim that the use of BIM saved 9,000 drawings and 15,000 hours. ñTypically weôd expect 100 major design clashes on a job of this size to slip through the net, at a cost of around £350,000,òGordon Alexander confirms. On this job there were just two. 3D modelling also made it easier to access the M&E installationsò (10)

With regard to the Performance Gap, ARUPôs industry review (11) on the matter noted that the key contributing factors are grouped into 3 areas ï design, construction and operation. Within the realm of construction, the over-arching problem highlighted is that design intent is not carried through to the building site, either as a result of Value Engineering, Contractor design changes or insufficient construction quality.

This is backed up by the CIOBôs review of Skills in the UK construction industry (12), which highlighted the biggest perceived shortage to be in Trade and Technical skills on site. Furthermore, the majority of those interviewed considered the construction workforce had insufficient skills to deliver buildings within a BIM environment.

2.5 What's the alternative?

Over centuries, the strands of expertise required to deliver buildings has remained relatively consistent; design ability, specification skills, project management, cost

tracking, general construction, skilled trades etcetera. In an almost constant state of flux and renewal, however, is the manner in which these skills are brought to a project, and by whom. Most notably, aspects of the modern roles of an architect, site manager, foreman and skilled tradesman were all frequently realised in previous centuries by the commissioning of a master builder - who would offer a comprehensive design vision, supported by the ability to realise itôs construction. Such a natural blend of design and craftsmanship has been a key contributor to the delivery ï and continued success ï of some of the worldôs most valued architecture, but over the last 100 years the two industry characters have become increasingly polarised. The advent of Design & Build procurement could have recalibrated the industry towards just that ï but instead, the longstanding consensus has been that this delivery mechanism has reinforced a Design *or* Build mentality.

In the current scenario, it is now clear that the overall performance of a building ï in terms of delivery, energy efficiency and occupantsôsatisfaction (and even delight) ï is being limited by the communicative separation between designer and constructor and, whilst many of the tools and skills exist to rekindle a fully collaborative delivery process ï the mind-set and opportunity may be lagging behind.

The solution, then? A recognition of the constructorôs role in delivering the most comprehensive design solutions, and the designerôs potential for ongoing contribution in the construction process. The practical realisation of this ambition is not necessarily that designers and constructors need to retrain to gain all the abilities of their counterparts ï although this may help as well. The manner in which constructors attain the understandings and nuances of a design concept is through substantial and natural communication with the design team. Similarly, a whole and overlapping communication with constructors on site (See Figure 2) will give designers a far more robust and impacting awareness of those issues that so frequently serve to dilute or render ineffective their original visions. Further than enlightenment of each party, however, a comprehensive re-engagement of the interlinking nature of this utopian relationship would undoubtedly lead to greater buildings all-round, and not just slightly higher-performing versions of our current construction stock.

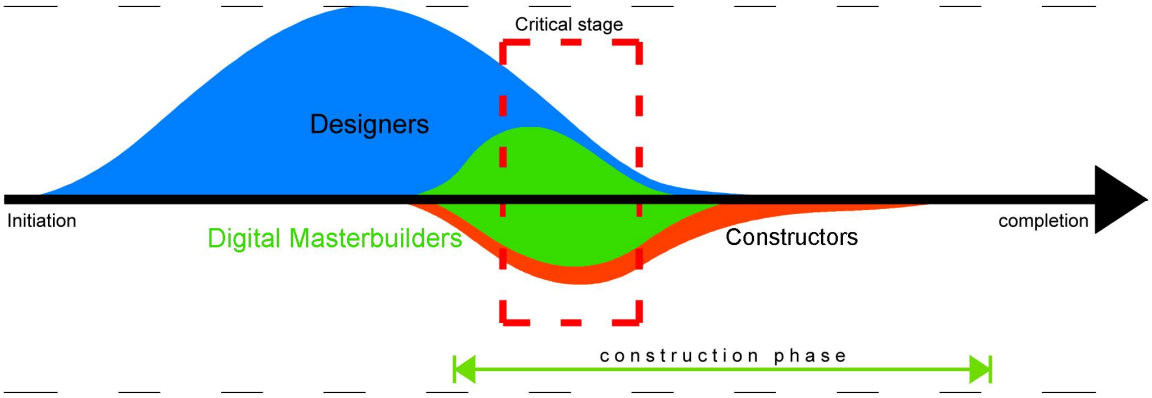

Figure 2: Revised Approach to Design Resolution

The impending excitement of this prospect is that BIM is intended - and indeed, equipped ï to be the methodology for creating this new breed of industry

professional; digital master builders ï professionals who contribute to the design *and* construction of a building through digitalised collaboration. Recognising this very opportunity, Previous Chief construction Adviser, Paul Morrell, suggested in 2011 that BIM could ñheralded the return of architects to the role of master builderò (13)

BIM encourages far greater levels of information flow between key stakeholders of the construction process, and fosters a communal ownership of the digital built environment. In its fullest sense, the architectôs drawings wonôt exist within total BIM; only extractable building plans that incorporate varying degrees of architectural, structural and mechanical data, for example. In this context, the constructor on site can be activated as a legitimate contributor to the design evolution of the building - feeding in specialist amendments, variations resulting from practical intolerances and as-built conditions throughout the construction process.

Digital Masterbuilders will, therefore, manifest from both ends of the traditional construction chain, but will crucially always occupy the most critical period of a project, when design is being transposed into construction. The scale of this phase varies enormously from project-to-project, but their presence would be felt throughout the programme because excellent buildings naturally evolve through the creative power of continuous, real-time, professional collaboration.

In considering the notion of a Digital Masterbuilder operating within the current construction industry, the undeniable hindrance of current digital technology uptake within the building site becomes acutely apparent. Even where designers may be increasingly accustomed to carrying out their duties within the context of a digitally evolved industry in their office-based realm ï they are immediately restricted by the previously discussed traditional communication methods of site meetings, phones and email when designs start being realised. The problem is much more pronounced for the forward-thinking constructor, who is invariably connected to a much larger web of interdependency with supply-chains, sub-contractors and independent specialists ï all (or at least, most) of whom will also need to engage in digital collaboration for it to offer tangible benefits.

Thankfully, there is potentially a significant opportunity within the industry to propel the construction workforce towards the Digital Masterbuilder solution, with 75% of contractors agreeing that adoption of newer communication technologies would be likely to lead to an improvement in construction quality, programme and cost. Moreover, most Site Managers consider that the Performance Gap would be reduced if communication between designers and constructors was more widely supported by digital technologies, such as video conferencing and 3D model mark-ups. (8)

Where there is clear acknowledgement that improved communication and collaboration could be supported, the onward issue is how such improvements are achieved, and what tools, systems and methodologies exist ï or need to be developed ï to support its manifestation on building sites.

2.6 A Digital Masterbuilder's tools

At its most fundamental, BIM ï as a methodology and approach ï is the plainly obvious way of accessing digital collaboration. It is becoming a proven process with the design stages, and there would seem to be relatively widespread acceptance

and, to an extent enthusiasm, that BIM will find its way into the constructors workflow in the coming years. Many upskilling tradesman interviewed at the Colchester Institute (14) have expressed an expectation that their day-to-day job will evolve within the next decade, as more digital tools are brought into the construction site under the umbrella of BIM methodologies.

Good examples of such digital tools are MagicMeasure, Issman and Daqri (15). MagicMeasure is an augmented reality tape measure for mobile devices. When a site worker does not have a laser or tape measure to hand - but undoubtedly has a phone in their pocket ï they can take a picture and enquire about the measurements they want to know. Issman is an app for phones and tablet that supports co-ordinated online snagging, whilst Daqri is a powerful new smart construction helmet, which offers possibilities for data overlays within workerôs field of view.

In respect of their ability for tools like these to assist with improved co-ordination of technical aspects within a construction project, this has to an extent already been demonstrated by greater collaboration and propensity for a right-first-time approach amongst design professionals. Clash detection programmes and multi-user specification programmes (such as NBS Create) undoubtedly offer improvements in the technical design, and it reasonable to consider that Digital tools focussing on construction issues such as delivery scheduling and task management could be equally as effective for constructors.

Similarly, the improved realisation of a construction project as a result of digital technologies being more widely adopted need not be a concept. Site managers have, for some years now, made use of CAT scanners, Total Stations and laser surveys to advance the accuracy of their setting-out and below ground work investigations and also lower their overall project risk profiles. The direct improvement in construction as a result is that buildings will typically (but not always! (See - Cambridge Cinema (16)) be built in the right place.

Importantly, however, the sample group of interviewed Site Managers also evaluated the relative contribution they felt digital technologies could make to certain aspects of a construction project and, above surveying, setting out and data management ï communication was ranked in first place (8). The current lack of Digital Masterbuilders is well explained by this assertion, where by far the majority of digital technologies currently available to the construction industry are either independent systems ï for use by individuals for their own quality assurance or record - or representative of fairly primitive collaborative objectives; for example, file-sharing software that allow access to other peopleôs data but little opportunity to engage with it. There are a few notable exceptions, which do offer greater overall functionalities such as Autodesk 360 and PlanGrid, but one canôt help but feel these are digitalising current communication preferences, rather than re-casting the fundamental relationship between designer and constructor.

2.7 What's the gap?

The primary issue with regard to communication between constructor and designer clearly isnôt so much about data not being accessible, as it is about the ***correct*** data being available when itôs ***needed***. The accuracy of design information is heavily

reliant on its relevance to actual on-site conditions and its ability to respond to variations and disparities ï some of which may have occurred just hours before the request was made by the constructor. In this context, the problem is compounded, if not created, by *time*. Similarly, any given *need* for information arises from shortcoming of data at a specific *time* that itôs presence on the construction site or design office would be of immense benefit.

The gap, therefore, forcing its way between good intentions for a fully collaborative approach to design and construction work, and its resultant project benefits, can be summarised as the incapacity to bring together the right skillsets and data in an expedient manner. After all, it has already been highlighted that constructors tend to rely on emails, site visits and phone calls; all of which are inherently not entirely reactive processes and, at best, may only be seen as offering intermittent real-time collaboration. In an optimised workflow, where finance and physical restrictions were not in place, this issue could likely be resolved by establishing project hubs wherein designers and constructors are all based on site, with complete availability to respond, update and amend the building design and construction as necessary.

This is obviously not a particularly viable solution, but it does pinpoint the aspiration sought through mobilisation of Digital Masterbuilders within a project; the embedding of skilled individuals who are ôhard-wiredô into the main project information system through technological means, allowing them to access, interrogate and inform the current data in real-time. The result of such an ambition would be the empowerment of a workforce to progress at pace, with greater accuracy and quality, and the hugely beneficial prospect that these Digital Masterbuilders would be both office and site-based, depending on their primary skills.

2.7 The filler

ACCEPT (Assistant for Quality Check during Construction Execution Processes for Energy-efficienT buildings) is a European-funded research and development project that aspires to create a suite of hardware and software systems that will address this very complexity. The crux of the project is a collection of three software applications, designed for use by construction workers, site managers and consultants, which will interface with one another through context-relevant hardware of smart glasses, tablet and desktop computers respectively. The three applications ï CoOp, SiMa and Dashboard ï will link to a central data store which will collate all data created and collected by the hardware on the project, thereby offering designers and constructors the ability to engage with otherwise unavailable (but nonetheless, relevant) project information.

The specification of functionalities will not, for the most part, be particularly innovative; many items such as check-listing, portable 3D model viewing and individual profile management are not ground-breaking in their own right. Similarly, the use of tablets on site and desktop computers in design offices is also commonplace. The innovation within ACCEPT, however, is the intention to bring so many of these useful functionalities into one environment so that, for instance, a site manager can allocate an element of construction work within the 3D model to a specific workerôs task-flow for the day, and update a quality checklist and digital plan

in real-time so that designers can track and input on a particular issue, should it arise. Once more, the most compelling innovation being sought, even within this example given, is the real-time capability - and it is expected that this will be delivered through use of smart glasses on the construction site.

The ACCEPT project itself is a three year programme, intent on realising a number of successful pilots for this system across Europe. The project consists of partner companies and research institutes from six countries, who bring expertise in software development, analytics, design and construction into a consortium. Specifically, it is anticipated that by equipping designers and constructors with the ACCEPT system, there will be extensive deployment of Digital Masterbuilders within the industry who can directly improve construction quality and achieve significant improvements in overall building energy-efficiency.

3.0 Conclusions

3.1 Is any of this achievable?

BIM has already set a lot of the groundwork ï there is an expectation and understanding that the industry needs to change. It is slowly dawning that if you follow the same procurement and delivery path as in the past then you will end up with the same mistakes in a different format.

The revolution is already happening; many site managers use a smartphone and apps, cat scanners and digital cameras. In concession, this doesnôt quite amount to a revolution, because most people looking around from within the industry cannot see the monumental strides in collaboration and quality that have been hypothesised in this paper. Nonetheless, the construction site is evolving, and those people on it day-to-day are prepared to try out digital technologies if there is any prospect that they will lead to improvements in quality, cost and programme. As alluded to in Chapter Two, Site Managers are in strong agreement that further adoption of new digital technologies ï and particularly those that support improved communication between designers and constructors ï would have a positive effect on each of these three components of a construction project. (8)

3.2 What are the barriers to uptake?

Projects such as ñBuild London liveò as well as real schemes by some of the leading contractors are showing that the BIM approach can work on site but there are some very basic stumbling blocks ï

- Time/money/training
- Wireless and telephone coverage on site
- Infrastructure and hardware such as iPads and smart devices

Once we learn to communicate in a different mode, with models set up correctly and communication methods appropriate to the technology then many of the issues disappear quite quickly. As always with BIM, the key tenets of consistency,

collaboration and management need to be in place to allow a positive flow of accurate information.

Perhaps one of the most notable barriers to wider adoption, though, is the quiet perception that BIM is undeniably gaining momentum from the design-end of the project spectrum and is slowly consuming the well-established traditions of the construction site. There would seem to be some apprehension that the sea-change in working methodologies is being driven by designersô ambitions to make their roles more straightforward, and in some manner push construction management in a direction that it doesnôt necessarily want to go. This is not an undeniable concern, because the simplest translations of BIM ï those familiar graphs showing where effort needs to take place in a project ï have long suggested that more value should be placed on the design stages, so as to reduce mistakes, delay and cost overrun through the construction process. Taken literally ï this interpretation could point out a future stand-off between designers and constructors, as they battle to maintain identity within an increasingly fluid and ôstageôfree workflow.

In this context, the value of a Digital Masterbuilder - positioned at the forefront of collaborative engagement between those who are strictly designers or constructors ï is apparent to see. Equipped with tools such as the ACCEPT system, Digital Masterbuilders could, themselves, become the mechanism for breaking down other emerging barriers in the construction industry. After all, whilst it should not be expected that every stakeholder is a competent constructor and designer - it is becoming clear that the progress of digital technologies and associated process development is making it possible for some within the industry to assume such a hybrid role.

3.3 Where does it go from here?

The marketplace is beginning to fill with digital solutions for the construction site, many of which are tailored towards improved collaboration between constructors and designers. It is inevitable that, over time, the full relevance of some of these will be brought into question ï are they gimmicks, change-for-changeôs sake? The industry is, however, demonstrating that it has the appetite to reconsider the fundamental way in which it delivers construction projects ï and demand nearly always generates supply.

In time, the complexity and power of digital systems will grow, and solutions such as ACCEPT will be given the opportunity by Digital Masterbuilders to challenge most things considered sacred within the industry; physical site meetings, paper filesé red pens.

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