Chapter 24
Removing Barriers to BIM Adoption:
Clients and Code Checking to Drive Changes

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ABSTRACT

Building information modelling (BIM) is not only an authoring tool for architects and engineers, but also for all stakeholders in the building programme procurement process. Analysis tools like code checking of building regulations and environmental simulations that can report on heating loads, daylighting and carbon use will push the adoption of intelligent modelling faster and further than previously thought. The benefits for clients should not be underestimated either and some are already reaping them where project certainty is to the fore. However, the professional language that architects and engineers espouse is a latent force that can run counter to fostering collaboration. An emerging professional, the Architectural Technologist, can bridge that divide and adopt the adjunct role of manager in the integrated project delivery.

1 INTRODUCTION

Building Information Modelling (BIM) has been around a number of years now but its unilateral adoption has been slow. There are a number of issues here and one is the entrenchment of the different professionals and their methodologies. While it is absolutely right for an architect to control aesthetics and space, nobody questions that it is equally right for the engineer to control the structure and/or services. What is questionable is their mindset and language, if there is to be the real possibility of shared data, and genuine cross-discipline collaboration.

Sharing data and collaboration does not sit well with the disciplines' involved in the building industry. Cicmil and Marshall (2005) elaborate and elucidate a scenario of pseudo collaboration, where a two-stage tender is hopelessly inadequate due to

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the intransience of the quantity surveyor (QS) in their perceived role of advisor to the client. There is no mechanism in place to allow the QS to enter into a collaborative state with the main contractor and no desire to either. Cartlidge (2002) probably summed it up best with "…quantity surveyors must get inside the head of their clients".

There are many forces at work to discourage collaboration (Porter 2007) including the treat of new entrants, the buying power of both suppliers and buyers, rivalry among existing firms and the fear of substitutes. These strong entrenched attitudes (Walker 2002) in the design construction divide were addressed in the procurement of Heathrow's Terminal Five (T5), delivered on time and to budget (Haste 2002), where such an environment was nurtured and encouraged (Ferroussat 2005). It was based on the principles specified in the Constructing the Team (Latham, 1994) and Rethinking Construction (Egan, 1998). Had BAA followed a traditional approach T5 would have ended up opening 2 years late, costing 40% over budget with 6 fatalities (Riley, 2005); this was not an option for BAA (Potts 2002). Carefully defining responsibility, accountability and liability, the focus was on delivery. Remuneration was based on reimbursable costs plus profit with a reward package for successful completion. This incentive plan encouraged exceptional performance with the focus on the issues of value and time. Value performance occurred primarily in the design phases and was measured by the value of the reward fund for each Delivery Team and calculated as the sum of the relevant Delivery Team Budget less the total cost of the work of that Delivery Team.

The time reward applied only during the construction stages. Here, worthwhile reward payments were available to be earned for completing critical construction milestones early or on time. If the work is done on time, a third went to the contractor, a third went back to BAA and a third went into the project-wide pot that would only be paid at the end (Douglas, 2005). There was a no blame culture meaning that if work had to be redone the fault was not apportioned to anybody but the rewards would either be reduced or not awarded at all. This had the effect of applying a kind of peer pressure where it was in the interest of all parties not to fail, which created a place where the vertical silos of expertise were traded for viaducts of collaborative techniques. BAA took out a single premium insurance policy for all suppliers, providing one insurance plan for the main risk. The policy covered construction and Professional Indemnity (Potts, 2002).

Sadly, while T5 was collaborative it was not a virtually modelled project and when the first satellite building was recently commissioned this method was abandoned for a traditional method of procurement. Questions must be asked as to how much sway the various disciplines and the entrenched methods had in this change of mind. Or was the management chain of command too onerous. The team structure had a hierarchy of several layers of management; the development team, the project management team, delivery teams and task teams. There was no common model to reference and the level of comfort of the construction manager may not have been too cosy. Construction managers have the lowest level of comfort, working with other professionals (under 20%), while owners, architects and engineers have nearly twice that level (Eckblad, Rubel and Bedrick, 2007), meaning that while the traditional demarcations have a good *bonhomie*, issues arise if the industry can afford this luxury anymore.

2. BACKGROUND

2.1 The Professional Architectural Technologist

Developments are underfoot to establish the technologist as a professional body with the ability to sign off work. The following is generally a synopsis and distillation of the relevant points in the new syllabi and proposals for content for

Figure 1. Heathrow Terminal 5 © James Harty 2008

a new course being tabled by the Dublin Institute of Technology (DIT).

To address the educational needs of the professional architectural technologist, the Dublin School of Architecture is intending to replace its three-year Level 7 Ordinary Bachelor's Degree with a Bachelor of Science (Hons.) in Architectural Technology (Level 8) together with a Postgraduate Certificate in Applied Architectural Technology (Level 9). The Postgraduate Certificate in Applied Architectural Technology is intended to lead to the award of a Master's Degree.

"New methods of design and procurement have led to changing roles within the design and construction teams, with Architectural Technologists frequently playing a key role as technical designers, and in doing so emerging as professional partners to architects, engineers and surveyors in the building design process.

...The RIAI welcomes the emergence of honours degrees in architectural technology ... and seeks to work with the educational institutions in developing a context for professional accreditation of the new degree programmes.

... Whether or not Registration is introduced, professional membership and accreditation systems will have to make provision for these developments one way or another" - Royal Institute of Architects in Ireland, President James Pike, November 2006

The vast majority of Irish Architectural Technology Graduate Network (IATGN) members have expressed a strong interest in obtaining further qualifications at undergraduate and postgraduate levels, where among other things the technologist should maintain proficiency in emerging computer application software in information technology in general and building information modelling in particular. The technologist should play a leading role in information management and quality assurance processes (*Part A - Self Study*, 2009).

The issues raised are many and varied. They include title, competences (limits and overlaps relative to the competences of an architect), function (responsibilities arising from competences as employee and in self employment), recognition of experience in place of formal qualification, authority to sign documentation, variable education standards, professional support for self employed technicians, and the implications of Building Control Act, especially the technical assessment process.

The impact of European Union policies and regulations on the building industry over the last decade has been considerable. Legislation in the areas of Building Control, Planning and Health & Safety, alongside the ongoing development of EU standards and other codes of practice, continue to inform and control an ever more complex legislative environment.

The EU Energy Performance of Buildings Directive (EPBD) requires the development of energy calculation methodologies and EPBD certificates of energy performance. Building Energy Rating (BER) and Dwelling Energy Assessment Procedure (DEAP) energy performance assessment have been developed in response to this, while Building Regulations have been revised to include for higher energy performance of buildings and renovations. All these developments require additional technical training.

The Bologna Declaration (1999) recognises that European higher education systems face common internal and external challenges related to the growth and diversification of higher education. Its goal is to create, by 2010, a European space for higher education in order to enhance the employability and mobility of citizens, and to increase the international competitiveness of European higher education.

Its objectives are the adoption of a common framework of readable and comparable degrees and the introduction of undergraduate and postgraduate levels in all countries, with first degrees no shorter than 3 years with ECTS-compatible credit systems

With the changing nature of building procurement and construction systems in recent years, some graduates have established architectural technology consultancy practices which offer technical consultancy services to architects in areas ranging from fire engineering and energy design to technical design and information packages. Opportunities exist for the development of technical design consultancies with the proposed new academic programmes aiming to address this need.

As a result of this, the intended outcomes are to:

- Engage critically and collaboratively with the architect in the building design process, using knowledge and understanding of historical and contemporary developments in architecture and architectural technology, with an understanding of the architectural design process.
- Engage critically with structural, mechanical, electrical, fire, acoustic and other engineering disciplines, applying knowledge and understanding of engineering design in the management and coordination of consultant design input in the building design process (ibid).
- Engage critically with cost control consultants, applying knowledge and understanding of cost measurement, quantification and control, and the role of the QS in monitoring the cost impact of technical design decisions in the building design process (ibid).
- Engage critically with domestic and nominated specialist design sub contractors, using an understanding of design and construction procurement processes and contracts in the management and coordination of contractor design input at post tender and construction stages of the building design process (ibid).
- Engage critically with the building contractor in the building design and construction process, using understanding of site practice and procedures and of building contracts (ibid). No other institution is offering this degree of critical engagement at the moment in an official capacity, while many are seeking to address this new

development soon. Also it should be noted that only within the technologist field is there the wherewithal or the ability to dovetail all the above mentioned collaborations in a meaningful way. Sure enough a hierarchical management structure can supervise the process but having this intricate interaction with the other disciplines is the technologist's domain.

2.2 BIM at DIT

The application of these aims is then further developed into modules for the delivery of the course content. The course modules are intended to run over the latter three years of the four year undergraduate programme. There is a progressive and comprehensive build-up to the graduate's education, which structures the exposure and presupposes achievable outcomes so that the levels are realised in tandem with the student's studio work.

Module 1 aims to develop the learners understanding of the role of the architectural technologist on the design team, using the building model to explore the collaborative roles of the architect, technologist, structural engineer, mechanical & electrical engineer and QS in the building design process.

The learning outcomes are that the digital model is used to develop the architectural design in collaboration with the architect/architectural student, that it is used to coordinate engineering design input in collaboration with the structural and mechanical & electrical engineer/engineering student, and that it is used to coordinate cost control input in collaboration with the QS/QS student.

The design process is to compare and contrast the roles of the architectural technologist, architect, engineer, quantity surveyor on the design team, and to participate in design team meetings playing a technical design development and coordination role

Module 2 aims to develop the learners understanding of the role of the architectural technologist in the construction process, using the building model to explore the input of the specialist design sub contractor / fabricator and construction manager in the building design and construction process.

The learning outcomes are to demonstrate an understanding of interoperability, to use the digital model to coordinate sub contractor design input and to use the digital model to extract and elaborate construction detail in collaboration with the construction manager/construction management student.

The construction process is to compare and contrast the design roles of the design team and the roles of the domestic, nominated, specialist and design subcontractor and building contractor, to describe the sequence of principal events in the design and construction of a building, to compare and contrast traditional subcontractor drawing development coordination systems with BIM, and to participate in construction team meetings playing a technical design coordination role

Module 3 aims to develop the learners understanding of the use of BIM on facilities management, post-construction measurement and geomatic data integration using a variety of related software applications. The learning outcomes are that on completion of this module, the learner will be able to use BIM for building energy performance analysis, to compare and contrast the roles of the architectural technologist and the geomatics surveyor, and to participate in construction team meetings playing a technical design coordination role (*Part A - Self Study*, 2009).

2.3 PG Cert Applied Architectural Technology

The PG Cert aims to develop and deepen the learner's sense of professionalism, building on their undergraduate learning and their experience in practice, and provide the opportunity to plan career development and prepare for further study in areas of architectural technology specialism.

The aim of the Construction Legislation module is to develop and deepen the learner's understanding of construction legislation, regulations, codes and standards, building on their undergraduate learning and their experience of construction legislation in practice.

The aim of the Regulations in Practice module is to develop and deepen the learner's understanding of the building regulations in general, and the areas of fire safety, universal design, and sustainable design in particular, building on their undergraduate learning and their experience of building legislation in practice.

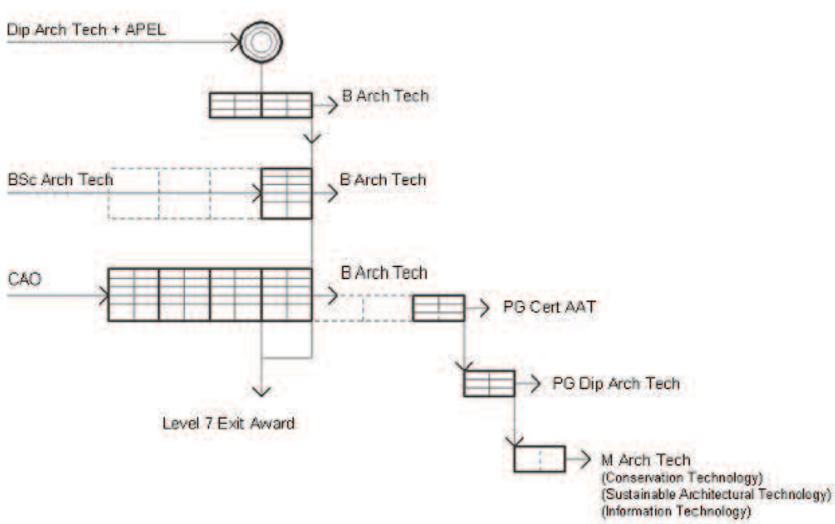
The aim of the Procurement and Contracts module is to develop and deepen the learner's understanding of the building procurement process and the use and application of building contracts, building on their undergraduate learning and their experience of construction legislation in practice.

The aim of the Management & Quality module is to develop and deepen the learner's understanding of the various management processes involved in the practice of architectural technology, building on their undergraduate learning and their experience of construction legislation in practice (Postgraduate Certificate in Applied Architectural Technology, Part B - Dublin School of Architecture January 2009).

Generally it can be seen that the modules mimic and duplicate the Professional Practical (Part III) exam for architects. A new post has been advertised and filled for a senior lecturer to run both courses with what seems to be identical content. The only difference is that the architect will complete this after a minimum of three (bachelor) plus two (currently a diploma) with one year practical training and two years professional practice (i.e. 8 years), whereas the technologist will require an extra year in total (9)".

These are significant changes and developments in the course structure. Likewise it also shows a definite tendency to position the technologist in a more professional light. In Spain the *architecto* and the *tecnico* sign construction contracts jointly. In The Netherlands certain master's courses allow technologists to become registered architects. Many countries have technologists that go on to complete an architectural qualification but many IATGN members see this

Figure 2. Department of Architectural Technology (DIT): Planned programmes.



as a damning compromise and a general disservice to technologists.

The course content also reflects the growing importance of BIM as a procurement tool.

2.4 Design and Procurement

Requests for information arise because of inadequate documentation and drawings in the first place. Christopher Alexander (Notes on the Synthesis of Form, 1964) describes three scenarios of designing content and form. The first being in unselfconscious societies where the building process has not changed through many generations and the content relates directly to the form, since the person building it lives in it where the community has established workable solutions. The second happens when artisans or craftsmen emerge to do specific tasks within the community. It is not their house so repairs and chances for mistakes become possible.

This is not due to any lack of quality in the work but because of an increase in the magnitude and complexity of the work. This is a semi-conscious state and the way the work is done with an image of the content required together with an image of the form delivered. The last scenario is a formalisation of this process where the images are formalised (a formal image of content and a formal image of form) so that they can be better recognised and controlled. This is a fully conscious state and the building industry essentially endorses this method with formal procedures for checking and controlling the work that procures a house or whatever.

This can be seen with the various parties working together to produce a building. Previously light tables would be used to correlate the various tasks, or overlays of digital drawings could provide a method for formalising the process being undertaken. But the light table does not even feature in the cartoon industry today and like the balls of twine that QS's used to take off measurement are long consigned to the trash can. More common is the emergence of technical meetings now occurring on site, often in parallel with the architect's site visit, but chaired and run by technologists. These usually comprise of the subcontractor and the technologist who puts work into context, as well as the sequence and first/second fixes required to complete the work.

This avoids witnessing such situations of a bracing member finishing up one meter inside an external wall because nobody told anybody what to do, where it was done knowing full well that there would be extras to rectify the error. Also complete facade panels being delivered on site and mounted where the openable lights clashed with the position of the stepped back columns, meaning they were unopenable. These meetings avoid the need for rework and try to keep everything up to speed and on time, if there is a critical time path. But this happens on site and increasingly the model can resolve these situations earlier in the studio. This situation also highlights the demise or the architect/clerk of works relationship.

The paradigm in modelling came when an acceptable method was found for sharing or distributing data. It allowed ownership or more importantly intellectual rights to be retained by the various design team members' work, while allowing them to remain stakeholders in the project. This cannot be underestimated. Its motto is to do the work in one place and only once, no more checking, cross checking, and red-lining other consultants' drawings in the traditional method but rather having an open source know-how which is not compromised with fears of one expert being undermined by another or lumbered with finding component collisions later in the procurement process, on site for instance.

This has now moved the debate further in that the stake-holdings (of ownership) in the model have a requirement for overall co-ordination. There is a need for the management of the sharing, integration and tracking as well as maintaining the datasets which Jonassen (2005) sees as a rather awesome endeavour. The situation is poised for the introduction of the BIM manager. There will be a need for overall management and leadership but where it will come from is now the major issue for all concerned. If the model is to be hawked from one discipline to the other then where is the co-ordination? Who ensures that it is kept functional, or merely operational, for want of a better word?

Under traditional project procurement, other disciplines in the design team could be reluctant to get involved above and beyond basic and initial observations before the architect had substantially formed the building. This was so for many reasons, primarily because it would be abortive work if the architect made a litany of changes, which was often the perceived case. Generally the other team members were there at this stage to ensure that space was allocated for when they got involved at a less turbulent stage. Typically, this would mean a structural engineer staking a need for a certain size ceiling void for the placement of structural members together with a service engineer who would place all ducting and pipework in the same void. This was seen as an appropriate level of involvement at this time and was seen as adequate cover for their involvement later. There is a professional language and protocol at work. Traditionally too this led to exactly where problems occurred on site when there had not been thorough cross checking of the various disciplines' work to avoid such errors. The effect of this initial approach meant that it could occupy much of the remaining (project) time being resolved.

To alleviate this problem the various disciplines often shared their drawing files so that overlays and references could be checked and rechecked by the differing parties. However, the problem with this was that only those areas which had been drawn could be checked. If a difficult part of the building had not been fully drawn then it could not be fully assessed or resolved until it came to light, often on site, leading to additional instructions, delays and counter claims.

This applies equally to more straightforward parts where the fault was not so obvious. Generally the experienced practitioner learnt this through hard won knowledge from previous projects; it was a 'learn-as-you-go' scenario that came at a price the industry has been happy to pay to date. Also it could only be tolerated on projects following a similar vein. New ground heralded a new battle field, with all that entailed.

Young, Jones and Bernstein (2008) see the value in BIM being the integration of the tools and the process. The AGC BIM Forum (*BIMForum.org - home*) sees this as a dichotomy where the individual users are identified as 'lonely BIM' as opposed to the IPD practitioners which it calls 'social BIM'.

BIM has intelligent objects and distributing them makes sense. Authoring tools allows design to be embedded, construction to be sequenced, and scheduling to be broken down into elemental works; while a costing model can be implemented, fabrication can soon replace traditional shop drawings and ultimately an operational model can be handed over to the client. While Young et al (2008) see architects rejuvenating themselves as the main drivers of BIM with 40%, contract managers and general contractors come in at second on 18% with a combination of both at 14%. Owners are next at 13%. However, this is the current situation. It remains to be seen if architects can remain at the controls.

2.5 Project Certainty

On a project in Hong Kong (Fong, 2007), the developer saw things differently. The project is Swire Tower at One Island East and here the technology has both aided the building process, while acting and giving feedback, as the lower floors have risen above the busy city streets.

"The design and procurement methods being used on the job represent a full integration of information into a single 3D Building Information Model. This 3D database is being used simulta-

neously to coordinate architectural, structural and mechanical design information. As well as producing detailed project specifications for cost estimation and construction scheduling... (it discovered) *...close to 2000 clashes leading to a cost saving of close to $13 million. The contractor is updating the virtual model as the building is being constructed, so that the model can be used for operations and maintenance once the construction is completed".*

For the developers it was about project "certainty", knowing what was going to be built and at what cost. While this certainty gave control back to the architect, it was the client who is instrumental in the procurement method (Fong 2007). Aouad (2004) noted many trends against BIM adoption in Hong Kong and they are worth naming as they surmise the general thinking at the time. They included that there was no perceived need to produce BIM, existing CAD systems were adequate, BIM would not reduce draughting time as it was not flexible enough, it was not required by clients, and finally it was not required by other team members. (*Papers: The utilisation of building information ... [paper 2005/8]*, 2005).

Comparing this to the McGraw-Hill Smart Market Report on Interoperability ('Young, 'Jones, & 'Bernstein, 2007) a mere three years later there are stark differences. Under factors influencing BIM, 68% believe that there is less draughting, 49% cite client demand, 47% improved communication and out of nowhere comes code checking at 25%. There are many others but the remainder of this chapter will focus on code checking and its implications. This will also impact on client demands and hopefully make the case for the new technology.

There are many causes for this and prime among them was the American Institutes of Architects (AIA) national convention in Las Vegas in September 2005 where Thom Mayne (Strong, 2005) said the immortal words: *"If you want to survive, you're going to change; if you don't, you're going to perish. It's as simple as that".* The AIA championed Integrated Practice, Interoperability and Integrated Project Delivery, which are all variants of the same thing; collaboration. The other significant fact was that when Autodesk acquired Revit which Chuck Eastman claims had the same effect as legitimising BIM.

3 MAIN FOCUS

An allegorical tale is of a student, returning from practical training, at a young practice that had recently won a provincial town competition for a new public building in the town square. Essentially it had no right angles and the municipality made it a priority that there was complete disabled access in the winning scheme. In the first instance it was modelled in Sketch-Up to satisfy the architects that the new situation met with their design criteria. This demonstrated a good knowledge of the relevant building regulations and their application. Then it was modelled in ADT in order to demonstrate to the structural engineers that their A4 key junctions worked precisely where they had been chosen but failed when the section line was moved a mere meter up or down.

Close collaboration with the engineer ensured a pin jointed solution could be employed resolving key parts of the building in the studio and not on site had the errors not been highlighted when they were. This was one of the reasons for the school's change to a modelling basis soon afterwards, in an attempt to minimalise the number of programmes students' needed to master. It is also an example of the technologist understanding both discipline's modes of working and responding appropriately to both. Finally, it illustrated client requirements being assimilated and the solution being fittingly presented, by the technologist (student).

Another factor, parallel to this legitimisation process, was that computers were providing a means of building previously unbuildable works for architects like Frank Gehry (*DIGITAL PROJ-*

ECT - frankgehry.). He set up Gehry Technologies (GT) to realise his unique forms.

Two consecutive projects are the Walt Disney Concert Hall in Los Angeles and the Guggenheim Museum in Bilbao. With regard to the concert hall, Gehry found himself beset with cost overruns and the project was shelved for a period due to lack of funding. It finally cost an estimated $274 m. which is more than five times the $50 m. budget at the start of the job.

In this situation Gehry has said that his position went from having the parental role at the start of the project where he was in control, to an infantile one when cost overruns threatened to scupper it. He says: *"... then the construction people say just that: we know what to do - straighten out a few things - we'll get it on budget. Of course the owner finds himself very confused about this ... "*, and the focus moves from the architect to the contractor. The architect has lost face in the eyes of the owner and the contractor is now seen as the saviour, if the building is to be realised. He goes on to cite that: *"in our time you have the Sydney Opera House where poor Jørn Utzon gets clobbered. It's a horrible story. It practically destroyed the man's life"*.

Conversely, when tendering came about for the Guggenheim Museum in Bilbao, GT sent a member of staff over to Bilbao to train the bidders in the software prior to tender, to show them how to extract the quantities of this complex building where not one piece of steel is the same. This was pretty unique in 2004. The result was that *"...they came in 18% under budget on just the steel alone. There were six bidders and the spread between them was 1%. Now that is knockout, rare, you don't ever get that"* said Gehry seeing more than a fifth being knocked of the budgeted estimate.

In the Walt Disney instance, not having the model and being forced to overlay 2D drawings to collaborate contributes to massive cost overruns. In the Guggenheim instance, making the data available removes error and the need for contingencies because of the complexity of the building. This heralded a new dawn for Gehry where he now uses selective tendering, and to qualify he insists on their software being used and bidders learning how to use it and the virtual model to extract quantities. This has put him back in charge, restored him to the parental role in his dealings with clients, now that he can more precisely control the process. The intelligent model (BIM) has done this for him.

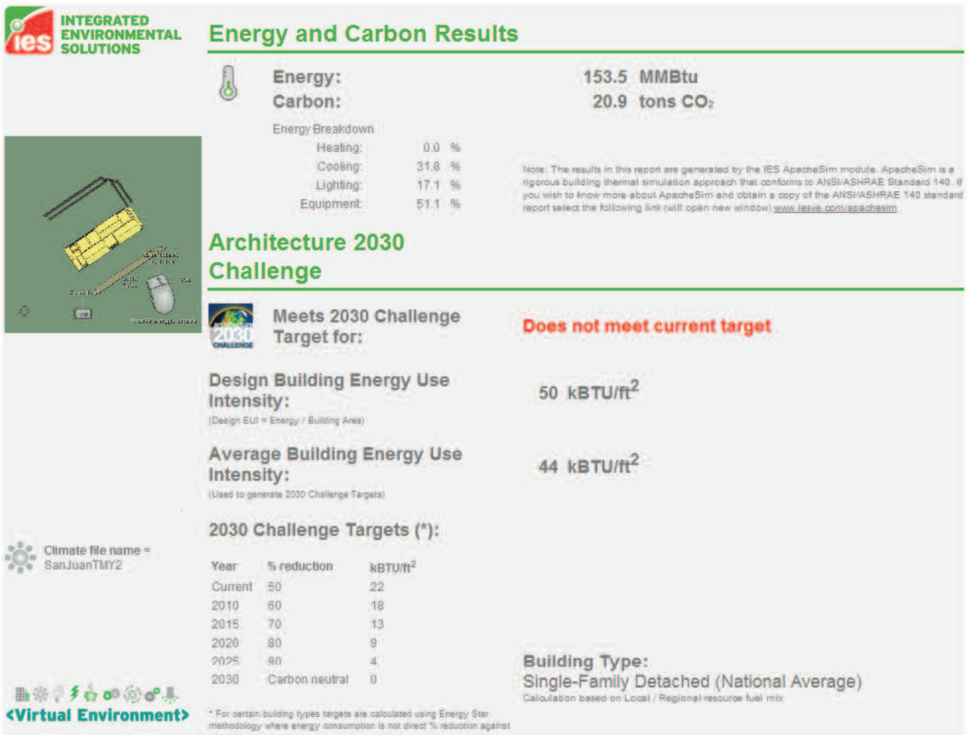
From the evangelistic viewpoint this is the clarion call, but from the practical position there are many other issues. Primarily there is ownership. Who will own the model, who will manage the model, and who will co-ordinate the model's passage through its turbulent growth. In the Gehry case it is a star architect and in such lofty situations those choosing or succeeding to work with him have identified this type of work and accept its challenge.

In a more standard situation there is also the temperament of the disciplines concerning when they want to get involved. Many firms have broached this new technology inhouse and are reaping the rewards inhouse. There is still a reluctance to share the model. That said the output is often shared but this is in the form of overlays not inner access to the crown jewels. This also manifests where there is no common software base. The Industry Foundation Classes (IFC's) were developed to eliminate cross platform translations but simple tests of translating the most elementary model objects show that this is far from satisfactory.

Sustainability

Recent publications from the EU have made it clear that concerted efforts to cut carbon emissions are crucial to the future of economic and social sustainability of the region. While there is broad agreement in principle, practice is entirely another matter. The shear amount of data and the

Figure 3. Quantative Result of whether an ongoing design meets criteria or not during design proposals (does not meet current target- red text).Generated report by IES -ve software



shear spread of influence is enough to scare even the sincerest practitioner. Thankfully a rack of solutions are making this task a little easier.

In initiatives like 2030 Challenge and 2010 Imperative, the scientists have set goals and the politicians deadlines which make the problem more manageable. Categories and weightings have been established (including energy, water, surface water, materials, waste, pollution, well being, management and site ecology) in which ratings can be drawn. These then give an indication of how successful the exercise has been, carbon-neutral being the highest of six results.

These nine categories are broken down to credits (energy is 36.4%), and 90 out of the 100 achieves the highest score. So far so good, except that researchers are falling over themselves to provide toolkits to calculate these categories and the waters are becoming muddied again. However, of the list one British Research Establishment Environmental Assessment Method (BREEAM in the UK) stands out.

Analysis software that produces BREEAM reports can use the building information model to give quantifiable results. This has significant appeal. The Netherlands are now considering adopting BREEAM and Denmark is also seriously looking at the situation. This means that the model can provide information about compliance, and also provide a place where experimentation with values (insulation for example) can quickly render results. Changes to the model are reflected in the reports and there is a seamless interface were the toolkits plug directly into the modelling programme.

This is code checking in practice. The University of Applied Science in Berlin is using modelling and analysis software in the studio to inform the process of the design in an ongoing, way while interrogating the model with '*what-if*' scenarios and achieving sustainable solutions with scientific results.

David Conover describes buildingSMART as a concept which is the opposite of building dumb (Conover, n.d.a; Conover, n.d.b). He looks at automated code compliance looking at model codes, standards, and federal, state and local regulations that are based on those documents, working towards;

"... seamless communication between public and private sectors through building smart using smart codes,

"... the delivery of better and more efficient public services and enhanced public safety,

"... more timely and accurate approval and validation of design, construction and continued use"

"... who wouldn't like to get a building permit in a day or approval?"

Checking then involves testing each piece of code with the instance. Three results are possible; first is that it is not applicable, second that it is exempt, and lastly that it is required and so passes (Conover, n.d.a; Conover, n.d.b).

A confidential memorandum between an international well known architect and their local enablers (a large well established national firm) notes *"that the best way to exchange information for co-ordination is as 'dumb' geometry"* and that 'X' and 'Y' *"will experiment with exchange of files with differing file formats to determine the best method of exchange"*. This high level low level solution is akin to the slide rule analogy of computers by Chuck Eastman, who said *"... it (BIM) is a big a leap forward from convention CAD as a computer is from a slide rule.*

4 FUTURE TRENDS

So if the pressure is not coming from within then what will drive the changes? Clients were instrumental in the DWG format being adopted as deliverables more than twenty years ago, and they appear in the factors influencing BIM as having 49% influence. Code checking's appearance at 25% in the McGraw-Hill Report on Interoperability is significant in that there was not widespread checking then, so it must be determined as a '*wish-list*' item ('Young et al., 2007).

Pazlar & Turk (2008) found that moving a simple wall in and out several programmes led to data being dropped. Typically, a field would have no corresponding field in the new format and if not critical would be dropped. On passing back that field would be voided. Even using IFCs evidence was shown that all export functions were not supported. It could be as innocent as the wall hatch or pattern being lost in a vertical section, but even so it meant that the operator had to be vigilant *"not blindly trusting the mapping process"*.

Alan Baikie of Graphisoft argues in Building Design's 2008 World Architecture 100, an annual survey of the top architectural firms in the world, that larger firms are slower to invest heavily in terms of money, time and effort in their migration into the 3D realm, leaving the door open for nimbler firms (Littlefield 2008).

5 CONCLUSION

Many would say faced with this evidence that it is unbelievable that it has not been adopted in greater numbers. However, there are questions of ownership which latently must be having an effect. IPD outlines that the collaborative process demands full commitment from all parties but there is a certain amount of entrenchment from the professional disciplines towards engagement. Before each stakeholder in the supply chain makes their contribution, there can be a stand-off, with the misconceived view of avoiding abortive work.

It is seen as a baton passing exercise where there are sign-offs at each work stage so that there is a finite body of work to be tackled by the remaining team members. It harks back to traditional methods and without a custodian or manager it is stagnating. Confidence has not been established and more showcase projects are needed. With a defined role of adjunct manager the situation can be reversed.

This coupled with the work that educational institutes are doing to produce technologists, leads me to believe that they will be the custodians of this new idea. This can be seen already with Frank Gehry who has established Gehry Technologies, an independent holding company that provides an indispensable service for him but who also act on their own as can be seen with Swire properties in Hong Kong.

Project certainty was an issue for the Swire Tower. GT became the BIM process consultant for this project and used their expertise to create the model prior to construction. The contractor updated the model as the building was constructed, so that the model could be used for operations and maintenance when the building was completed.

Finally, sustainability with its need for indicators is fostering a code checking environment to deem compatibility in the carbon neutral race. Coupled with code checking of building regulations and all related laws which can be codified or enumerated, this is leading to a beach head where clients will demand the today building permit over the typical three month turn-a-round often experienced by the conventional method. Clients like certainty and will drive this cause. The latent uptake by the professionals can be alleviated by the adjunct manager, a role which can be fulfilled by the technologist, who has the unique ability to understand the professional languages of all or most of the stakeholders, together with the know-how gleaned from an intimate knowledge of the model. They are trained to know what each profession does and they are trained to know what each project needs from the other professionals.

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KEY TERMS AND DEFINITIONS

BIM: Building Information Modelling is a method of procuring a construction project through the use of a common model, or a visualised database.

IPD: Integrated Project Delivery is the collaboration of all stake holders in a project working together as a team and sharing data so as to minimalise duplication in its reuse and to facilitate exchange

Technologist: The (Architectural) Technologist is a new profession growing out of the technician's role but with wider skills and deeper knowledge of building procurement, construction management and collaborative methods

Code Checking: Code checking is a digital method that can interrogate the model's database and using analysis tools can robustly establish model compliance with statutory legislation, local planning and building regulations as well as sustainable targets. It requires writing all rules and regulations into machine readable code which is then applied to the digital model. A report is generated or non-compliance highlighted for remedial attention

Sustainability: Sustainability is a performance demand for environmentally friendly buildings. There is a target requirement of achieving carbon neutral buildings in the very near future with quantifiable data

Model Management: Model management is the ability of sharing and integrating data while tracking and maintaining the data flow across many disciplines and from inception of the project to decommissioning of the building

Authoring Tools: Authoring tools are the means used to build the information model.

Analysis Tools: Analysis tools are the means used to interrogate the virtual model to check for compliance and highlight areas for remedial action