

BUILDING INFORMATION MODELLING –EXPERTS’ VIEWS ON STANDARDISATION AND INDUSTRY DEPLOYMENT

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ABSTRACT

The goal of the single building information model has existed for at least thirty years
and various standards have been published leading up to the ten-year development of
the Industry Foundation Classes. These have been initiatives from researchers,
software developers and standards committees. Now large property owners are
becoming aware of the benefits of moving IT tools from specific applications towards
more comprehensive solutions. This study addresses the state of Building Information
Models and the conditions necessary for them to become more widely used. It is a
qualitative study based on information from a number of international experts and has
asked a series of questions about the feasibility of BIMs, the conditions necessary for
their success, and the role of standards with particular reference to the IFCs.

Some key statements were distilled from the diverse answers received and indicate
that BIM solutions appear too complex for many and may need to be applied in

limited areas initially. Standards are generally supported but not applied rigorously and a range of these are relevant to BIM. Benefits will depend upon the building procurement methods used and there should be special roles within the project team to manage information. Case studies are starting to appear and these could be used for publicity. The IFCs are rather oversold and their complexities should be hidden within simple-to-use software. Inevitably major questions remain and property owners may be the key to answering some of these. A framework for presenting standards, backed up by case studies of successful projects, is the solution proposed to provide better information on where particular BIM standards and solutions should be applied in building projects.

KEYWORDS: Building Information Models, Industry Foundation Classes, objects, standards, case uses, frameworks

INTRODUCTION

Representation of all the information needed to describe buildings throughout the whole design, construction and management process has long been an objective for those applying information technology in building [1]. The use of computers to replicate traditional ways of representing building information: 2-dimensional drawings, perspectives, engineering calculations, quantities, management networks and costs, has been easier to achieve via separate applications, while it has long seemed that an integrated model should be possible. The object-oriented tools to build such a model have now been available for some time, but the need to integrate the many people involved in the process, and the ways in which their information is

organised, have been a limitation on the widespread use of Building Information Models. Standards are critical when communication between different specialists, internationally and over long periods, takes place. The most ambitious programme for standardising object models of buildings, the Industry Foundation Classes [2], has been developing for over ten years and the resulting protocols have still mainly been applied in test projects only. There is now an awareness of the cost of not having interoperability and some major building clients are starting to encourage their teams to use the standards compliant tools that are becoming available.

The knowledge about design intentions is defined at an early stage of the process and can be modelled in a way that allows it to be retained throughout the process. This requires clear semantics and modelling techniques that are explicit to all involved in the later stages of the process. The US initiative on a National Building Information Modelling Standard [3] is initially focussing on an International Framework Directory which allows it to define briefing requirements precisely. It is proposed that these should be retained in the BIMs used through the process since continuity is essential if the original intentions are not to be lost.

While CAD systems facilitating the production of 2-D drawings were being taken into widespread use some researchers and system developers started to envisage more advanced building representations, which could solve some of the more demanding data sharing functions that graphics-oriented CAD systems cannot. The software technology which seemed to offer the solution to this was object-orientation, where the information packets that the software manipulates are created based on predefined classes. This paradigm is currently in wide-spread use in the computing industry both in programming languages and also as an organising principle for systems

development [4], and is particularly successful in the creation of more complex applications.

2-D drawings produced with computers are mimicking the limitations of 2-D media. Conventional representations are widely understood and there is experience that establishing equally effective conventions for 3-D representations including graphical, textual and numeric data, and maintaining them throughout the life of a construction project if not that of the building itself, has been very difficult. The concept of objects is starting to achieve this but there is a tendency amongst users of CAD systems to equate objects with physical elements thus limiting the knowledge that can be retained by modelling concepts and the way in which requirements can be translated into physical form. A survey carried out in Finland in January 2007 [5] has shown that use of manual drafting by designers is falling by 55% while that of 2D computer draughting is falling by 32%. BIM is planned to grow by 85% but is defined as any CAD system using 3D data and includes the use of 3D visualisation.

Digital building descriptions using objects which belong to predefined classes have usually been called building product models [6], although some software vendors have recently coined the new term building information model (BIM) for essentially the same thing. The research concerning such models was envisaged as early as in the late 1970's [7] but started to gain more momentum around 1985, when the ISO STEP standardisation project started. STEP stands for Standard for the Exchange of Product Data [8] and tries to solve the data exchange needs of a large number of manufacturing industries. Early attempts at building standardisation within STEP included the global AEC reference model [9] and the Building Systems Model [10].

In the mid 1990s the product modelling standardisation for the building domain was taken over by an industry consortium called the International Alliance for Interoperability (IAI). The first version of the Industry Foundation Classes (IFC) was issued in 1997. Although there are some software applications which have been implemented based on the IFCs, and these have been tested in a number pilot projects [11], neither the standard nor product modelling are widely used in practice.

A growing awareness of the importance of the management of the standardisation and adoption processes for the eventual success of BIM, has led us to initiate a study of a number of standardisation projects of central importance to the use of IT in construction. This work has first focussed on the basic level of standardising CAD drawings, ISO 13567 – Organisation and naming of layers for CAD [12], and secondly, in this study, on the more ambitious level of integrated modelling of construction information as objects, with particular reference to the IAI Industry Foundation Classes.

CAD layering was the subject of the first part of this project. This study of CAD layers used a combination of literature review and survey with domain experts and has been reported elsewhere [13]. The main results were that CAD layer standards based on ISO 13567 have been implemented, particularly in northern European countries, but are not very widely used. A major problem which was identified was the lack of resources for marketing and implementing the standard as national variations, once it had been formally accepted.

There are also other initiatives, particularly those associated with proprietary CAD systems, and the objective of the study reported in this paper was to identify the factors that make these initiatives more or less successful. Several case studies of trial

BIM projects have been reported, for example from Finland [11] and Hong Kong [14], but, to get a broader view, it was decided to carry out a qualitative study using experts from different countries to give their informed opinions on the state of BIM/IFC models and their usage. 18 experts from 7 different countries responded to structured email questions. In addition a workshop with six leading international BIM experts was arranged in August 2006 and one expert was interviewed in person, the interview being recorded. The comments have been analysed and a synthesis of the views is presented in this paper.

Recent experience of trial projects and a growing awareness of this technology by large client groups have led to some particularly influential papers being written about the state of BIM. These written sources have also been used as an input to this paper. A study by the US National Institute for Standards and Technology [15] has estimated that the cost of not having interoperability in the US Capital Facilities industry is about \$15.8 billion per year. This has stimulated new initiatives there to develop a National Building Information Modelling Standard, driven by large client bodies such as the GSA which commissions federal buildings. In Finland, there has been a major commitment by the public sector and large construction process stakeholders to IFC usage. One of the leaders of the Finnish initiative, Prof. Arto Kiviniemi, recently presented an informed and critical view of IFC developments at the Toronto CIB conference [16]. In the UK the fifth terminal at Heathrow Airport has been a target project for building modelling and a leading consultant to the project, Mervyn Richards, has summarised the need for changing business processes rather than just promoting superficial differences in technology [17]. These and other discussions have raised awareness of the need to apply appropriate technologies and standards

that can be adopted easily by companies that already have most of the communications and computing facilities necessary.

In addition to case study reports, one important source of information is provided by a number of recent surveys of industry uptake and perceptions of BIM. A study of Virtual Design and Construction and BIM in the US is being carried out at CIFE using a web survey [18]. At 1st November 2006 it had 39 responses from AIA, CIFE and CURT members and had reviewed 32 projects. The analysis suggested that Virtual Design & Construction / BIM was being used in all phases of design and construction. It now addresses key process problems; most respondents perceive high value but cannot quantify benefits and there are established programs for future expansion but also impediments which should not stop progress. The IT Barometer surveys of three Nordic countries were carried out in 1998 and 2001 [19] and showed low awareness of CAD standards and virtually no use of BIM. This is due to be repeated in 2007.

In January 2007 The Finnish Funding Agency for Technology and Innovation commissioned a web survey among persons on the mailing list of their construction industry R&D programme SARA. In total 86 company experts answered the survey [20]. From the viewpoint of this study the key question was: "Has your organization participated in projects where the participants utilized shared product models".

Among the design companies a majority (76 %) had used products models (52 % in under 10% of projects, 22 % in 10-60 % of projects and 2 % in over 60 % of projects). The corresponding figures for other types of companies including contractors was 45 % overall YES with a detailed breakdown of 33 %, 9 % and 3 %. Interestingly Product modelling was the clear top priority for increasing ICT use in

the next two years among designers (85%), whereas the other stakeholders had project extranets for document management as top priority (40%). The results from this study cannot be extrapolated directly to the industry as a whole, since companies (and experts) on this mailing list represent the most innovation-oriented in the Finnish construction industry. However, the results indicate clearly the current development trend in Finland.

METHODOLOGY

Broadly-based, quantitative surveys in the construction industry on IT-use have until recently showed widespread ignorance and little usage of the IFC standard. In order to find the critical success factors for implementation and use, it was decided to carry out a qualitative study based upon the views of a number of experts in IT development including those defining and implementing standards, end users and property owners wishing to enforce them. A small number of questions were asked by email on the potential for BIM generally and the specific contribution of the IFCs. Respondents were told that their views would be reported anonymously and that they could reference relevant papers or web sites. They were offered copies of the analysis when it was complete. The emails were collected during autumn 2006. The questions are shown in Table 1.

| General BIM questions | IFC specific questions |
|--|---|
| 1. Is it possible to create Building Information Models which can contain and coordinate most of the data needed for design, construction and management of buildings? | 6. The timing and duration of the standardisation effort in relation to the general technical development of BIM technology |
| 2. What should be the role of standards, both formal and de facto, in the definition of BIMs, that can be used nationally and internationally? | 7. The resourcing and management of the technical IFC definition work |
| 3. Do these standards already exist or are new ones needed, and who should develop, implement and promote them? | 8. The simplicity versus complexity of the standard |
| 4. What benefits will result from applying standardised BIMs, and to which members of the building team, including owners and facility managers, will most benefit accrue? | 9. The question of freezing versions of the standard for longer periods |
| 5. What changes are needed to the building design, construction and management processes to ensure that BIMs provide the greatest benefits? | 10. The resourcing and management of information about the standard |
| | 11. The development of IFC compliant software by vendors and related quality issues |
| | 12. The commitment of major client organisations and construction companies to the standard |

Table 1. The study questions.

By the end of 2006 18 responses had been received from experts in 7 different countries: Denmark, Hong Kong, Holland, Norway, Sweden, UK and USA. The greatest number was from Sweden and UK. Professional backgrounds were approximately divided equally between architects, engineers, contractors and IT specialists, with about half of these having academic posts. Their responses were grouped according to the questions posed and common elements or differences noted and particular insights or recommendations recorded. Key statements and questions that need to be pursued further have been derived from these by the authors.

ANALYSIS OF THE RESPONSES

QUESTIONS RELATED TO BUILDING INFORMATION MODELLING

1. Is it possible to create comprehensive BIMs?

Predictably all the responses were qualified, and about equal numbers fell into the ‘Yes, but ...’ and ‘No. but...’ categories. Other responses were that it is theoretically possible or that information modelling is nothing new. The reservations were mostly about the lack of definitions, which the IFD library project aims to solve, and the lack of good software, with CAD vendors using the term in their own ways. BIM has become an important topic in the US and some managers are said to be ‘going for glory’ by attending meetings of the NBIMS. Most uses of BIMs are in specific areas with contractors using it for spatial coordination of projects and briefing trade contractors. The single building model is seen as cumbersome by some and will need to be used in conjunction with other forms of data. The Information Delivery Manual being developed in Norway should help implementation. It may be easier to coordinate through a single database and to keep the geometrical model simple. The single BIM has been a holy grail but it is doubtful whether there is the will to achieve it.

Key statement: The Building Information Model may have to be used first in specific areas.

Key question: Which areas of BIM will current interest by property owners ensure become used?

2. The role of standards, both formal and de facto, in the definition of BIMs

Predictably the respondents to this question all believed in standards but differed as to what should be standardised, how formal standards should be and whether they were likely to be observed. The ability to transfer information digitally throughout the building process has emphasised the need for standards. For wide recognition it was felt that they should be formalised internationally by ISO, but that de facto standards which were widely used should be capable of formalisation. The European approach was said to be irrelevant to the US where the industry is more disorganised and only procurement standards have any legal status. Diverse and changing project teams depend upon standards. Common libraries should be usable by different BIMs. Proprietary standards are suspect and de facto ones, while faster to produce, often leave out essential elements. Standards should not be a barrier to creativity and innovation. They may apply to: language, products, elements or processes. Those relevant to construction mentioned include: IFC, ISO 12006-3 Barbi/Lexicon, IDM, STEP steelwork, UN/CEFACT, Process Protocol, Uniclass and Avanti [21]. On the question of timescales most were pessimistic about widespread usage, even nationally, and questioned whether the lead was coming from the US or Europe. The critical factor was whether the intended beneficiaries of BIM standards appreciate the commercial need.

Key statement: Standards are nominally supported, are most effective nationally, but need ISO endorsement.

Key question: Are property owners aware of how suitable BIM standards could benefit them?

3. Do the standards already exist, and who should develop, implement and promote them?

Many standards relevant to BIM exist but it was suggested that there is a lack of a framework into which they could fit. The IFCs are the ones to be encouraged but could be improved. BIM standards are poorly marketed and incomplete. They need to be seen to be used by the top firms and should have support from clients, industry bodies and governments. Development should be by experts from the construction industry with implementation by software companies. Some believe that useful standards do not exist and any new development should start from an unchanging metaphysical structure and ideas. More classification and data definition work is required. Object libraries, according to ISO 12006-3, are being developed in the Netherlands and their standard is being proposed to ISO TC59/SC13 as an international standard. There is no standard for modelling structures. In Hong Kong some projects show that the architects lead the BIM process but other consultants have little incentive to follow. There is a lack of standards for facility management.

Key statement: A framework is needed into which all BIM standards can fit, including data definition.

Key question: How should such a framework be defined to include all phases of construction and the future?

4. What benefits will result to whom from applying standardised BIMs

Almost no one questioned that benefits from BIMs were achievable and to all involved in the process. There were a few examples of savings achieved on individual projects and the NIST report [15] was often quoted, and suggests that 2% greater efficiency could be achieved immediately and 10% after a few cycles. The main beneficiary would be the client followed by the facility managers, but all in the supply chain could benefit. One problem is that work by one member of the project team

might benefit another and benefits ought to be shared by all. The greatest benefit from BIM would accrue over the lifetime of the building hence Private Finance Initiative projects, tendered for construction and operation over many years, might gain most.

All these potential benefits depend upon the people and software being used. In the US 4D software combining 3D models and project management has an immediate impact. The type of procurement is a factor, with fixed price contracts using BIM benefiting the contractor but design and build contracts less likely to do so. In the UK the Heathrow Terminal 5 and Stansted Endeavour House projects showed benefits to the whole supply chain, but this only applies to single solution projects with interoperability and use of standards. Some other projects have shown a 100% increase in profits. Manufacturing industry has achieved over 30% savings from integrated IT but this is unlikely to be achieved in construction. In Europe productivity in construction is rising at only 10% of that in manufacturing. No one provided information on the cost of setting up, training staff and applying BIM systems, an area that should be explored further.

Key statement: Distribution of any benefits from BIM will depend upon type of procurement and responsibility for operation of facilities.

Key question: What have been the costs and benefits of the projects already applying BIM?

5. What changes to the process are needed to ensure BIMs provide the greatest benefits?

It was generally agreed that major changes were necessary but perhaps the BIMs and standards currently available needed to match industry procedures better. Institutions

should recognise the need for a new specialism in applying technology, standards and modelling, and being responsible for spatial coordination. Decisions need to be made earlier in an integrated process and time can be saved by parallel working.

Technically BIM solutions are almost fully available but the commercial drive to apply them has had little effect yet. Education, from site operatives learning to read, write and handle numbers, to students getting more information on BIM, is essential for eventual success. If the pressure comes up from new graduates and down from commercial management, BIM systems will eventually come into general use. There is a need to integrate project teams through giving responsibility for the whole process and partnering. Information needs to be recognised as a strategic asset and paid for. It also needs to be constantly updated.

There are benefits from applying BIMs to industrialised building. Some changes proposed are: integrating design and specification, automating regulations and creating a collaborative umbrella. Some of these changes are starting to happen but BIM does not appear to be serving the needs of the construction industry yet.

Key statement: Changes to the process are already starting but there may need to be a special role to manage BIM, and special education.

Key question: How should a BIM specialist and training be built into the construction process?

QUESTIONS ON THE INDUSTRY FOUNDATION CLASSES

6. The timing and duration of the IFC standardisation effort

IFC development has taken about 10 years so far. Some feel that this was too slow and that resources were inadequate. Others feel that the timing is about right now that BIMs can be run on desktop computers. However general deployment of BIMs and IFCs could take 10-20 years. Standards development has been by interested and qualified people but management in the US do not understand their significance. They recognise BIM but do not apply it. In smaller countries like Finland, Norway and Singapore there has been more success. For instance the R&D funding agency TEKES in Finland has been quite instrumental in promoting IFCs and is concerned with doing the right thing whereas stakeholders in the US are said to be only concerned with the lowest price. Comprehensive standards such as the IFCs are not generally understood and are not being adopted. The IAI has been around so long that people have forgotten it or become bored. Some software products based on it are available but the scope was too broad. The move to include specific formats is good. IFC development started at the right time but with little knowledge of existing standards and has delayed the deployment of BIM. STEP AP221 might have been a better starting point. There is a need to support specifications and costs. A user friendly interface is essential. There is a need for a technical audit of IFCs and an enquiry into what support vendors are giving.

Key statement: The IFCs have a new stimulus through US property interest in BIM and the IAI re-branding as BuildSMART, but easy to use software implementations are still needed.

Key question: What is the real commitment of software vendors to implementing IFCs and other standards?

7. The resourcing and management of the IFC work

Almost all said that resources and coordination were inadequate. Is this the fault of the IAI? The best people need to be paid to work full time on the IFCs and vendors should contribute. More companies are beginning to invest in BIM. Pioneers have to take the first steps before commercial companies join in. Development of IFCs has been confined to a small circle of enthusiasts. IAI resources and membership may now be decreasing owing to development and adoption taking too long. If CAD vendors really want interoperability they can provide it but it may limit sales of their software. Users do not see that they have a problem.

Key statement: If benefits to property owners can be quantified from case studies, resources could be generated for raising awareness of BIM/IFC.

Key question: How can potential changes in the process through BIM/IFC be presented in economic terms?

8. The simplicity versus complexity of the IFC standard

The IFCs are complex but this need not be apparent to the user. Less complexity means less functionality. Mobile phone standards are easy to use because they are built into the phones. W3C OWL could supersede some aspects of IFCs. Simplicity could be introduced through subsets eg: views, a stable core ISO PAS and ifcXML. Models need the elegant simplicity of some drawings with less explicit information and more tacit knowledge. There is a need to test translators. Simplicity is paramount and leads to easier understanding and implementation.

Key statement: IFCs should be presented in the simplest possible terms using any relevant techniques.

Key question: How can IFCs be built into common and specialist software applications?

9. Should versions of the IFC standard be frozen for longer periods?

The general feeling was that IFC versions should be frozen for longer periods to encourage development of software. Individual suggestions were for 2 or 4 years. If not it will be impossible for all implementations in the world to be in step. An upward migration path between versions is essential. There should be an advised method for managing versions. Segmentation into application domains might meet development requirements without having to revise the whole standard. Some outsiders exaggerate the difference between versions. There has been a stable core to IFCs for some time. This has been added to but not changed.

Key statement: A framework for BIM standards could include timescales planned for IFC versions.

Key question: What management advice is needed to help users to choose appropriate standards from such a framework?

10. The resourcing and management of information about the IFCs

Promotion of IFCs is critical to their success. Organisations like ISO can help this. The EU does nothing although IFCs are used in their research projects. Technical presentations tend to put off the people who should be supporting them. Awareness of IFCs appears to be improving via semi open source publication. The latest BuildSMART initiative and web tools are improving marketing and dissemination.

Key statement: As stated previously owners expecting savings should support promotion of BIM/IFC and publicise their effect on their projects.

Key question: Could case studies from all parts of the world be collected and presented together with economic analysis?

11. The development of IFC compliant software by vendors

Development and quality testing should become self regulating eventually. Poor software will be superseded. The construction industry is too big a market to accept sloppy software. The better products may become de facto solutions. Some vendors implement IFCs because they have to rather than because it is the right thing for them. ArchiCAD and Allplan were pioneers in BIM support. ADT and now Revit 9.1 have import and export facilities. IFC Models have been passed between ArchiCAD and Revit with some objects not defined in IFC 2x2 missing. Some vendors are actually obstructive. Testing of exchanges has been discouraged. Quality testing levels have now been raised from lax to stringent. There needs to be a reality check on the IAI who claim that IFCs are used across the world when they are mainly used by academics.

Key statement: Related to a framework of BIM standards there should be information on vendors' commitment and testing of their products.

Key question: Would realistic assessments of IFC use, linked to leading owners and projects, be more effective in promoting BIM/IFCs?

12. The commitment of major stakeholders to the IFCs

This is critical to the success of BIM and IFCs. IFCs are not yet used and most industry is unaware of them. Development has been top down. The people who produce drawings do not care about IFCs but if there are products to help them they would make use of them. Why should construction industry firms commit to something irrelevant to their practice? There are few committed individual users and if they move the initiative is lost. Some major government clients in Norway (Statsbygg), the US (GSA) and Finland (Senaatti) are beginning to take IFCs very seriously. The Digital Construction project in Denmark [22] and HITOS [23] in Norway are examples of BIM initiatives. There is also growing commitment in China but the UK government does not seem to be aware. There is a lack of investment here both when the industry is busy and when there is little work. In Hong Kong clients are taking the lead with some aware and some trying BIM pilots. They need to be told of the importance of IFCs. Clients who claim to be using IFCs should be surveyed to find out their real level of commitment.

Key statement: Perhaps IFCs should be presented as a little known secret that can give a competitive edge rather than as an obvious solution that all should be applying.

Key question: If clients were given a BIM standards framework, and simply presented statements of their real capabilities, would they indicate their current and future levels of commitment?

The following figure shows how the development of standards and software, and their application on building projects could be documented with references to more detailed information on costs and benefits and information on planned versions and releases.

A POSSIBLE FRAMEWORK DOCUMENTING THE DEVELOPMENT OF BUILDING INFORMATION MODELLING AND ITS APPLICATION

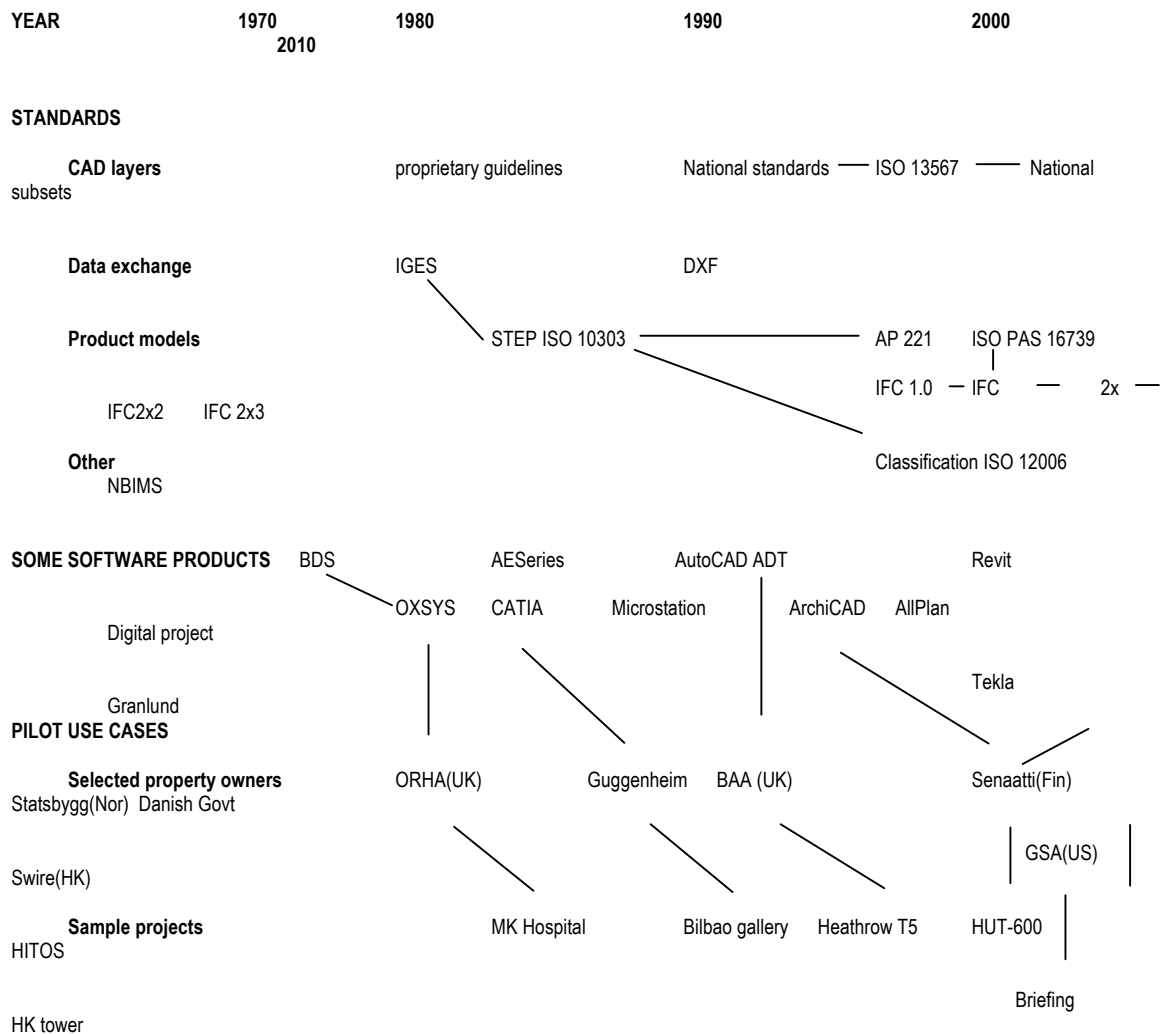


Figure 1. An example of the framework proposed for documenting developments in BIM

Figure 1. An example of the framework proposed for documenting developments in BIM

DISCUSSION OF BUILDING INFORMATION MODELS

The information collected is very diverse and contains contradictory statements but is based on much experience of introducing new technology to the construction industry. It raises as many questions as it answers but there has been no time to follow these up except by reference to some recent surveys and reports. The time seems promising for a renewed drive towards moving at least some leading property owners and their consultants and contractors into greater use of BIM and the standards that support it. The current experience mostly comes from public property owners. The object of this paper has been to distil, from the experience of a few international experts, some suggestions for better information, guidance and education on the economically viable means of using the tools and standards that exist and on further developments. The key statements following each question were an attempt to express the most common and constructive thoughts of those responding to it. Inevitably common themes occur that link the different questions and start to form a conclusion to this paper, while the key questions suggest further work related to these statements.

1. The idealistic goal of BIM has been to provide a single building model capable of being used throughout the process. This requires a huge leap which has, so far, mainly been applied on trial projects. There is some evidence that BIMs may have to be applied to particular processes first, the example being the NBIMS in the US which has started the process simply by requiring .pdf files that can be checked automatically at the briefing and early design stages. Successful implementation of standards or models at an early process stage can lead on to reuse later in the process but the question arises of who benefits from the extra work done by lead designers. The growing interest in BIM in the US is promising for future take up, but only about 60% of architects employing more than 50 people are using any form of BIM

according to the AIA report on the Business of Architecture, while the equivalent figure from the Finnish ICT Barometer [5] for all architects in Finland is 93%.

2. Standards are nominally supported; no one is against them but few apply them comprehensively. National groups have often been successful in implementing modest standards such as those for CAD layers, but international implementations need to be tailored for local cultures and conditions. Official endorsement, preferably by ISO, can give wide recognition but is no substitute for promotion and software implementation.

3. There are many standards relevant to BIM, not just those that aim to address the single building model. A framework for presenting relevant standards, showing their capabilities, stage of implementation and potential benefits, would help users to assess the appropriate level for them. The ability to move from the more basic standards towards those offering a comprehensive solution might then become more feasible.

4. The process in which BIMs can provide most benefit implies that there are long term relationships between those involved. These can be achieved by partnering so that consultants and contractors are appointed early in the process, by framework agreements allowing teams to work together on a series of projects, and by Design Build and Operate contracts where the benefits of using BIMs can be obtained over the lifetime of the building.

5. It was suggested that, in order to develop more advanced use of BIMs, there should be a special role in the project team for an information manager who could coordinate use of models throughout the project. This role coupled with better student education on the techniques of BIM would eventually drive firms towards a greater commitment.

DISCUSSION OF THE INDUSTRY FOUNDATION CLASSES

6. The IFCs have now had ten years of development, but with insufficient resources and dependence on a small number of experts. The signs are that some property owners are becoming aware of the benefits of BIM and that, coupled with the new image of the IAI as BuildSMART, there could be a new surge of enthusiasm. However there are complexities that need to be hidden within good software implementations.

7. There are now several case studies of the use of IFCs and the benefits obtained, both in quantity and quality, could be presented in a common format. This would help property owners to see the potential and might generate resources from them to provide the wider promotion necessary.

8. The IFCs could be presented in simpler terms. Sometimes the technical expertise of those producing them has deterred potential users. The concepts are simple and, if they can link directly to usable software, any relevant techniques should be used for this. There is much work on data dictionaries and these are essential to common terminology particularly internationally.

9. Concern was expressed about the timescales of different releases of the IFCs. Although there has been a stable core for some time, a framework for BIM standards could indicate likely release times looking forward several years.

10. Publicity is essential if particular standards are to be more widely used. Property owners should use successful case studies for promotion and identify the benefits they have obtained.

11. Software vendors are a key element in BIM and, where they have implemented IFCs, they should state their real commitment and to what level these have been tested.

12. The IFCs have been presented as the ideal solution to the inefficiencies of the whole construction industry. In the long term, and with continuing development, this may be possible but the key to use of many innovations is the pioneer users who achieve significant success. To promote BIM and the leading IFC standard as a secret route to competitive advantage could be a more successful approach.

This may seem to be contradictory in that wider promotion of BIM requires publicity for successful projects, but there may be very effective uses of BIMs that are unknown and quietly benefiting their users. What this study points toward as the main aid to progress in the wider usage of BIMs and the standards that underpin them, is the development of an authoritative source of information on all relevant standards and tools, case studies of their use, preferably with some economic analysis of benefits, and hard information on the level of conformance of software products. This is something that could be built from existing information, supplemented by further discussion with property owners who have used the tools that exist, and maintained by an international body such as CIB W78.

The framework that is proposed would relate the use of BIM standards and tools to the stages of a building project, would include information from case studies and CAD vendors, and cover as many countries as possible. The questions that arose from the work in this study could be answered by some further research and presented within an agreed framework that allowed for a range of levels of solution, presented with evidence of their benefits and looking towards future developments. Any new

project should ideally start by a consideration of the relevant standards to be applied and the software tools available to the project team. The client organisation, and initially this would be the large property owner who is already aware of potential benefits, would impose the agreed standards, provide any special resources necessary, and allow publication of the results as a case study. Their commitment to applying the standards would need to be stated and the procurement path to obtain maximum benefits is an essential element in achieving the objectives towards which so many academics, standards and software developers have been working for over thirty years.

CONCLUSIONS

There is now much experience of trying BIM solutions, either proprietary or conforming to formal standards, and this overview has collected the experience of a number of well-informed people, although there has been little from property owners. There is general agreement that knowledge about building requirements should be modelled in a way that integrates as much of the data that accumulates as design and construction proceeds as possible. Building Information Modelling is the way to achieve this but current solutions fall short of the ideals that have been sought since the 1970s. The formal standards, such as the IFCs are complex and have not had the resources for rapid development and promotion that their potential deserved. They are the best available given that proprietary solutions will always diverge. The missing element essential for the success of BIM is the conviction of property owners that they are not getting full value from the construction industry. This is now starting to happen with particular large property owners in several countries. Their willingness to

invest in organising their project teams in a way that allows all to contribute to, and make use of, the powerful models that are now possible, could complete the circle.

Those Pilot Use Cases that have been mentioned, and of which more are being documented, should provide the necessary evidence of benefits whether these are financial or contributions to better management of the process and realising the original intentions. Some clients who use BIM successfully may not wish to share their knowledge; however several of the leading property owners using BIM are public bodies which have a duty to publish their experience. Collection of these cases, such as those being invited for a forthcoming edition of the ITcon online journal, will help to inform and convince other property owners and their consultants and contractors that they are not being used as guinea pigs for purely experimental projects.

The framework suggested in this paper is a preliminary outline for something that ought to be developed into a precise tool allowing comparison of cases. It is based upon the ideas collected in this study but needs to define how the knowledge obtained from real projects should be defined, particularly the economic factors which could convince new users of BIM. The body of experience that could be built up would be of particular value where property owners had commissioned a series of projects in which BIM experience develops. These should show that, particularly where similar project teams are used, experience grows from what may be painful beginnings into a fruitful deployment of well understood technology retaining the knowledge that accumulates through the process.

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APPENDIX

GLOSSARY OF ABBREVIATIONS

| | |
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| AIA | American Institute of Architects |
| CIB | Conseil Internationale Batiment |
| CIFE | Centre for Integrated Facilities Engineering |
| CURT | Construction Users Round Table |
| HUT | Helsinki University of Technology |
| IDM | Information Delivery Manual |
| IAI | International Alliance for Interoperability |
| IFC | Industry Foundation Class |
| IFD | International Framework Directory |
| ISO | International Standards Organisation |
| NBIMS | National Building Information Modelling Standard |

NIST National Institution for Standards & Technology

ORHA Oxford Regional Health Authority

STEP Standard for Exchange of Product Data

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