Standards for Information Exchange and Sharing: Business Benefits

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Introduction

Years of experience in the use of CAD systems in construction have convinced many people that the solution to data exchange between computer systems lies in the development of a neutral format which is independent of any particular system. Most of that experience has come from the use of DXF which is broadly accepted as a de facto standard (where the term 'standard' is used in the sense of a specification which sets down methods that are normally used within industry). Even allowing for the limitations of the DXF specification, it has provided the means for simple graphical exchange between CAD systems and it has shown the potential.

Technically, work has centred on the development of product model based specifications for information exchange and sharing. There is a general acceptance that product model based approaches are richer than specifications such as DXF since they are concerned with definition semantics as well as with representation and presentation. Technologies enabling specification of file based exchange and database oriented sharing of information are now well understood and there is a significant community of capable people working at the technical level. Enormous energy has been put into STEP and, more recently, Industry Foundation Classes.

However, development of standards for information exchange and sharing must ultimately support business goals. These goals are concerned with making the construction process more efficient and, in so doing, produce greater returns on investment for the organisations concerned. Demonstration that these goals can be achieved is necessary to ensure that there is continuing support for the required technical work. That is, a case must be presented that there are business benefits from the use of standards for information exchange and sharing and this business case must be understood by Chief Executives and Financial Executives.

With all the work that has occurred in this area, it would be reasonable to expect that a sound business case would have been made which could be used to support submissions for continued development work. This may be true for other industries but it is not the case for building construction.

This paper seeks to begin the collection and analysis of business case information which can be used.

Impact of Standards

In assessing the impact of standards, the following questions must be asked:-

1. What impact have standards had and are having?
2. What is the potential future impact of standards?

Current Impact

The first of these questions is relatively easy to answer. To date, product model based standards have had no direct impact on the building construction industry at all. The primary reason for this is that the models, which are required by software implementers in order to develop the software which will cause an impact, are not yet fully developed.

However, developments which have taken place have generated a growing interest and excitement amongst those who have taken time to examine their potential. Projects such as ATLAS, COMBI and COMBINE have demonstrated what can be achieved. More recently, the CIMsteel project has begun industrial deployment of the version 1 CIMsteel Integration Standards. Early indications of the use of CIS/1 in live projects are that it is proving extremely successful but quantified information is not yet available.

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Future Impact

Standards are more concerned with the adoption of a technology and its structural requirements rather than the name given to an application of that technology. Thus, in this case, we are concerned with the implementation of product model based technology and its natural progression to object based technology. On this basis, we can include formal approaches such as STEP, collaborative approaches such as IAI and OMG, and market driven approaches such as COM/OLE.

However good a technology, it will only be used if it can demonstrate a real benefit to industry. This was clearly identified by Andy Crowley of Leeds University in the recent ISFAA97 Email conference

"A common complaint heard from academics and software vendors is that those involved in the construction industry are resistant to change. I feel that this does a disservice to many professional people who are not so much "luddite" as realists. They will not take on technology because it is new, but because it is beneficial."

STEP Can Cut Up To 35% Design Time

C. van Tienhoven, in *Potential Benefits of STEP - Case Studies and Examples* (Shell Report No. IC94-101, November 1994) reports that, it is clearly demonstrated that good quality information plays a role to reduce costs and improve the effectiveness of a facility throughout its life and that current approaches to the exchange and sharing of information are costly. The case studies reported looked at the use of STEP and identified that "*a significant part of the cost can be reduced substantially if common standards are used*".

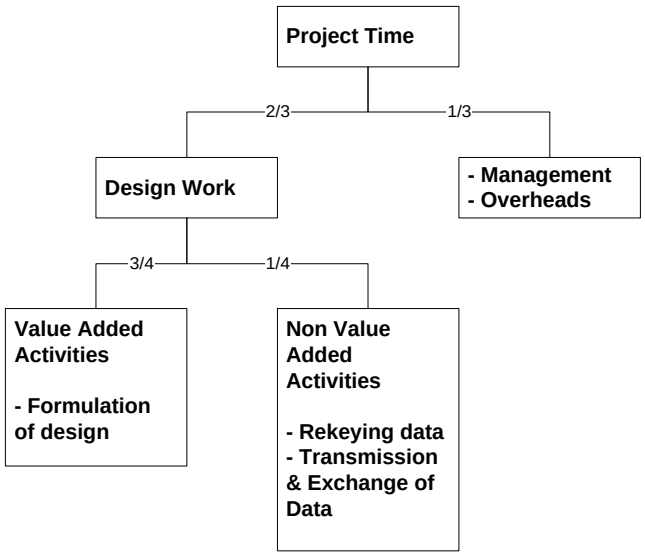
In design, it is estimated that reductions of 10% - 35% of design time and cost are achievable by standards based approaches.

No precise figures are given for the construction phase but the benefit of standard approaches for information sharing to allow for clash detection is considered to be considerable in eliminating the need for late redesign or corrections on site.

… and Over 5% of Maintenance Costs

Through proper implementation of a shared database developed according to standards based access technologies (such as the STEP Standard Data Access Interface), it is estimated that 5% - 15% of facility maintenance costs are achievable.

… whilst Rekeying Costs 1/6th of Project Time



Ineffective Data Exchange and Rekeying in a Contracting Firm

Ineffective data exchange and rekeying of information within a contracting organisation can account for up to one sixth (2/3 * ¼) of the available project time with a consequent financial effect. For any contracting organisation, this time is paid for as an overhead and impacts directly on the available profit from the project. Assuming a direct correlation between time and cost, around 16% of project value could be available to a contracting organisation as profit with the use of standards based product model technology.

Automating Commissioning Checklists

The commissioning budget for the Brent Bravo platform was £40m. It was estimated that automation of checklist compilation and their sharing amongst the contractors would have saved between 7.5% and 10% of the commissioning budget. Even allowing for the fact that commissioning is not usually taken so seriously within building construction, it remains reasonable to assume that similar savings could be available. On a £100m project with commissioning costs of say 2%, this would represent a return to the benefiting party (commissioning contractor or client) of £200,00 (notwithstanding the fact that the commissioning process would probably also be more effective and that construction results would be less costly to operate and maintain!).

A Contractors View

Expressing a personal opinion to the ISFAA97 Email conference, Graham Storer of Taywood Engineering discussed the importance of integration and his view of the future. He considered that STEP has been instrumental in developing both the abstract understanding and the concrete approaches to information modelling and process integration. However, the structure, culture and (lack of) drivers in the construction industry are such that mobilising effort and financial resource around something as demanding and tedious (yet unavoidable) as information standardisation is so difficult. He further considered that the greater sense of industry ownership and vendor participation within IAI have created an environment in which there may be a greater chance of success.

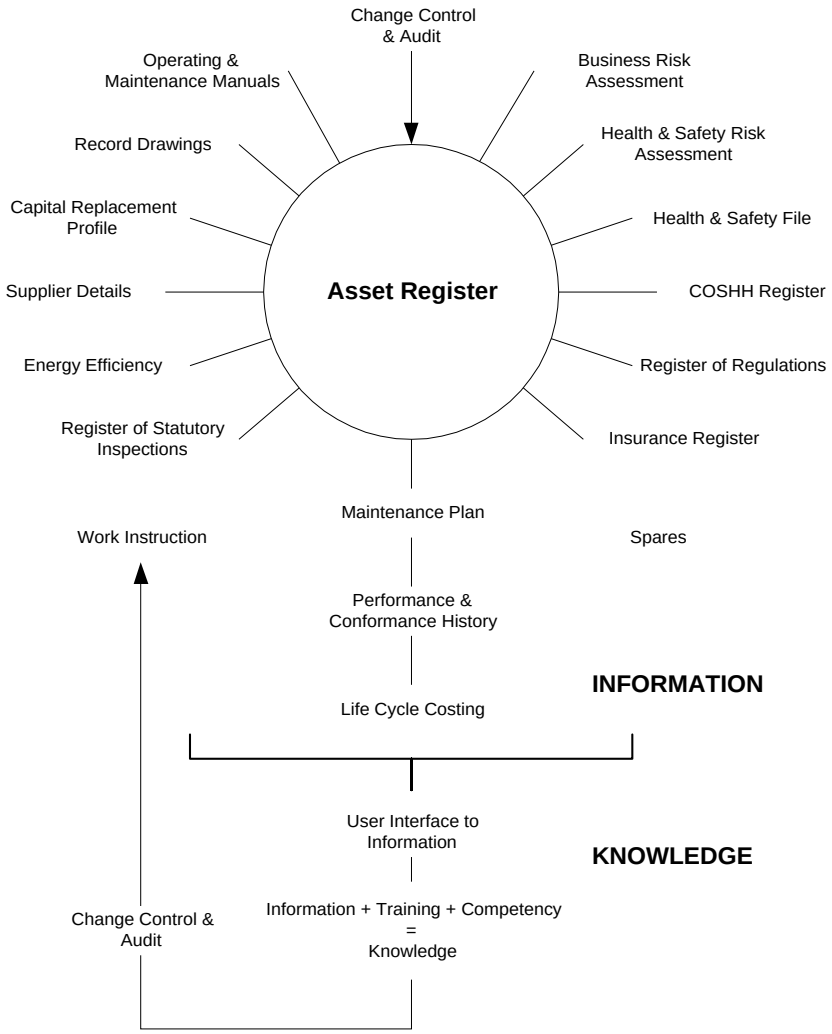
However, a principal point is that of being less concerned with the tools delivered or how they work or even when they do so as long as they deliver the information needed in a form that can be passed around different participants with different responsibilities and different software systems.

“The task is big, but vital to the construction industry, and particularly its clients, worldwide. How can adequate funds be generated for the rapid development of an information standard of good quality?”

Clients Expectations

Within the IAI UK Chapter, there is a strong belief amongst Client members that there are significant benefits to be gained from use of product and object model based technology. In the November 1996 issue of IAI UK News, Mike Goodman, Facilities Manager for Lloyds TSB plc considers that the benefit to his company of an engineering usage model and the resulting software will be by:-

- reducing final handover timescale (by having structured information readily available from designers and contractors at the time of handover)
- improving maintenance quality (by having available more relevant information concerning maintenance regimes)
- reducing maintenance cost (through the availability of detailed dsign, construction, commissioning and maintenance information)
- improving energy efficiency (through interoperability of applications software for load calculation, targetting and monitoring)
- reducing lifecycle costs (through availability of better information and better interoperable analysis)



Asset Management System

Ted Robbens of the London Stock Exchange, in a submission to the IAI UK Client Domain Committee, identified that the cost to building operators can be significant when handover information is poor, when field surveys may be required or where drawings are not available in CAD format. He also demonstrated that the design/construction phases of a project are information rich and that this information should be retained. The asset register should be at the core of operations for a building operator and this should be virtually a by-product of design/ construction. This is where he sees the interoperable philosophy of the IAI helping.

Matthew Bacon of British Airports Authority considers that the Client is the only person who has a continuing interest in the building from conception to operation and eventually demolition. He believes that information transfer and sharing based on product model technology supports the interests of the Client in both design definition (options, process flow, spatial relationships, areas and volumes, massing, building systems) and data requirements (historical costs, elemental order of cost estimates, elemental cost plan, management and control). In particular, the provision of information to meet the Clients 'need to know' is considered sufficiently important for Clients like Matthew to come together within the IAI to determine exactly what information the Client will need, when and from whom. The belief of organisations such as BAA and Lloyds Bank that they are encouraging their supply chain to become aware of the benefits which integration and interoperability can bring and then help to produce the product models and object definitions which will bring them about.

Estimating and Scheduling - What US Industry Has to Say

The following quotes are from customers and associates of Timberline Inc., a major supplier of computer based estimating systems. It explains their drive towards interoperable solutions for the benefit of their customers.

Kevin Pearson, Greenwald Cassell Associates

Greenwald Cassell Associates is a Virginia contractor who specialises in single-family residential work. The company has integrated its CAD and estimating processes.

"Through the automatic calculation of distances and areas, the integration has reduced my turn around time by at least 50%.."

Shawn Cannon, MIS/CAD Manager, Charming Shoppes

Charming Shoppes' in-house construction division, based in Bensalem, PA, was responsible for constructing over 300 Fashion Bug retail stores a year.

"Prior to integrating our CAD and estimating process, each store would take between 6-8 hours to take off. Integration sped up the process dramatically, allowing us to get to the same point within 10-15 minutes.Integration also eliminated at least 50% of the potential human error involved in the manual process."

Ted Yarbrough, Project Resource Group Inc.

Based in Clearwater, Florida, Project Resource Group Inc. is a cost control consulting firm concentrating on institutional and heavy commercial projects. CAD integration has played a significant role in helping to maintain cost on project design.

"If more architects could assign attributes to their design files, giving us the ability to link to our estimates,it would cut our time by 80%."

They also have benefited from scheduling integration.

"Scheduling integration saved our company $40,000-$50,000 in labour costs on one project. In scheduling a 10,000 line estimate, the benefit was very apparent."

Matt Lovo, Chief Estimator, Lowder New Homes

Lowder New Homes builds 230 homes a year on variations of 20 standard plans. According to Lovo, a key benefit of linking CAD and estimating is the ability to play "what if" games. This has allowed him to reduce and fine tune estimated cost on all 20 models, including available options.

"Our estimates are now only 1% to 2% off actual construction costs. We can also more quickly turn around estimates. The estimating process used to take us about six hours. Now, it takes about one hour."

Analysing Defects

The Defects Database is the heart of the Construction Quality Forum, a national database of building defects in the UK. To January 1995, they had analysed reports of 311 costed defects in non residential buildings. Whilst it cannot be precisely determined which of these defects are the result of information provision (or the lack of it) which could be rectified through the use of product model based techniques, the following defects are recorded which might be attributable.

Item or unit omitted	17
Size inadequate	19
Tolerances	14
Not specified quality	23
Misaligned or mispositioned	27
Wrong product used	9
Visually unacceptable	25

This total of 134 items represents 43% of the total. Assuming that half of these are information related gives a figure of over 20% of defects in non residential buildings being due to inadequate information.

More than one third of the defects cost £1000 - £5000 to correct whilst a further one third cost over £5000 to correct.
For the contractor, the cost of correcting defects is a reduction of profit whilst for a building owner, it is an increase in operational cost.

Analysing Where Models are Most Useful

Product and object model development has historically tended to focus on aspects of design with attention turning more recently to construction. Are these the areas where the greatest benefit can be obtained?

Potentially, the best sources from which to determine answers to this question are statistics concerning construction industry output. In this case, 'The State of the Construction Industry' report published in July 1996 by the Consultative Committee on Construction Industry Statistics in the U.K. is used as a basis for analysis.

Repair and maintenance work (including housing improvement) has grown in importance and now accounts for over 40% by volume of the industry output. Since 1955, its volume has grown by a factor of 2.5 compared to its level in 1955 whilst new work has grown by a factor of 2. It is also more stable when compared to the swings which have occurred in new work volume.

A profile of the building services industry by BSRIA indicated that building services accounts for 20% of construction output at a value of £20 billion. Its overall breakdown is similar to that for construction as a whole and therefore can be extrapolated. Turnover in design is £340 million with product supply at £6.2 billion and contracting at £13.2 billion (figures are higher in non domestic work).

There are a number of simple conclusions which can be drawn from these figures and, from these, some additional conclusions can be derived.

Simple Conclusions

1. Models which focus on contracting can demonstrate greater immediate impact than those focused on design.
2. There is a need to develop models which translate aspects of product supply into design and contracting needs and this need may be perceived as greater than that for design models.
3. Repair and maintenance models have a broadly equal importance to those dealing with product supply.

Derived Conclusions

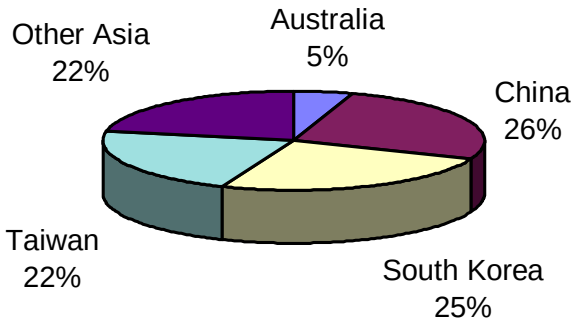
Simple conclusions which place design at the bottom of the list of importance ignore the fact that much of the information used by or developed from contracting or repair and maintenance has its roots in design. Therefore, design models do take on an importance greater than may be supposed from simple financial analysis.

It is most important that design models represent information which can be reused and extended by other participants and other project stages (and ultimately by other projects as a result of feedback) which gives design models their financial importance.

Australia Estimates Effects on GDP

In Australia, the construction industry generates A$30 billion in output at figures quoted in 1994 or 7% of Gross Domestic Product. Improving the efficiency of the non residential construction industry by 10% could result in a 2.5% increase in GDP according to the 'Strategy for Information Management in the Building and Construction Industry' published in November 1994. This figure is nearly twice as large as the next nearest sectors which are business services (near 1.5%) and residential building construction (around 1.25%). Taking both residential and non residential construction together, the impact on GDP of improving the efficiency of building construction is far greater than for any other industry sector.

The Strategy goes on to identify that construction is one of the most information dependent industries with information generated by and available through a variety of regulatory bodies, research organisations, product manufacturers as well as within projects. Within the Managing Project Information element of the Strategy, development of product data models and promoting their use was highlighted as a technology to help in achieving the GDP benefit.



Growth of Support Software

EPM Technology is a Norwegian provider of tools to STEP developers. They feel very confident about their market in all sectors. They are already supplying software to Loyds Register of Shipping and Det Norske Veritas for use in the shipbuilding market. However, they also have sufficient confidence in building construction to commit resources to supporting work through membership of the EU VEGA project and the Norwegian Forum of the IAI. Additionally, Leeds University are using this software for further CIMsteel development.

Kjell Bengtsson who heads EPMT's sales and marketing is convinced that the use of product model based technology will spread and refers to the adoption of EXPRESS as the data modelling language of the development of GIS standards by ISO TC211. He considers that we are moving towards a world of electronic commerce with product data technology playing a large part in this through its ability to provide open data. He identifies predictions that the Electronic Commerce markets in the US alone will grow by 25% per year. From a total of 4.5% of US commerce in 1994, it will grow to a total of at least 16% by the year 2000, a commercial value in excess of $1.65 billion.

Case Study 1

This case study is based on the use of conventional data exchange rather than product model based exchange. However, it is included because it demonstrates the benefit which can be gained by a client if contractual information is provided to them in a form which they can readily assimilate.

A recent activity within the new British Library has been obtaining record drawings for furniture layout in the Reading Rooms. Since the Library is a heavy CAD user, it was the intention that these drawings (of which there were over 100) should be transcribed to CAD. Initially, it was not thought that these drawings would be available in CAD format and consequently a programme for their development was instigated. At a late stage, it was discovered that the contractor had used the FastCAD system to create the drawings. These were made available in their native format and a data exchange contractor engaged to convert them to the DXF format for further exchange to the Library's AutoCAD system. The data exchange process took approximately one week and cost around £15 per file (£1500 in total). Rekeying would have taken around 2 months for 2 persons. Although the resulting files were not structured according to the clients internal data structuring standards, the files were considered to be acceptable in the short term for viewing. A later activity will be restructuring the files which will require part of the original intended programme time. It is expected that the overall saving however will be of the order of 25% - 40%.

Case Study 2

This case study is concerned with the exchange of information from a geometrically based (CAD) system to a property based (analytical) system. It demonstrates the very significant benefit to be gained from the exchange of product model information between systems of different types. This 'heterogeneous' exchange cannot be done to a great extent with current approaches such as DXF because the initiating CAD system has only limited capability for dealing with the nature of an object and the data views which may be required of it.

The design is for an air conditioning system for a single floor of a multi-storey office building. The floor contains 20 individual 2 person offices together with associated circulation, storage and sanitary spaces. The air conditioning system design involved cooling load calculation, ductwork system layout, duct system sizing

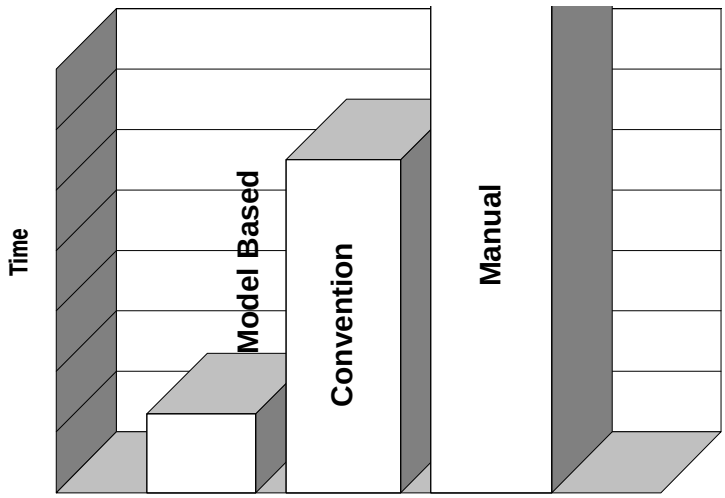
and calculation of required fan duty. Software tools included a CAD system for building and duct system layout and analysis software for calculations.

Conventional Approach

Layouts are drawn with lines and blocks.
Engineer must interpret elements from the drawing (with the help of the formal layer convention).

Any data associated with building elements is structured in a unique way determined by the CAD system.
This data cannot be exported as the analysis software has no conception of the data structure.

Engineer must manually enter element types and dimensions into the analysis software and add property data. Calculations are carried out.
TIME = 2 days



Comparison of Design Times

Model Based Approach

Layouts are drawn with objects which are defined directly as building or ductwork elements.
There is no need for the engineer to interpret as the CAD system knows what the objects are.

Each object encapsulates data describing its properties.
Data are structured in a commonly agreed manner which is known to both the CAD system and the analysis software.

Objects are exported to the analysis software which understands what they are and which can automatically add any default engineering data. Calculations are carried out.
TIME = 0.5 days

For completeness, a bar representing completely manual calculation has been added to the comparison graph. However, this runs well off the scale and into a time period better measured in weeks than days.

Case Study 3

A product model based software facility was developed for the transfer of information from an AutoCAD based building services layout system to dynamic thermal analysis software. This added product data to the geometric data within the CAD system. A test building was developed which consisted of a number of geometrically complex room shapes distributed over three storeys. The test building included overhangs and complex boundaries between spaces both at the same storey and between storeys. A trial showed that taking off of data from the drawing, rekeying into the thermal analysis software and calculation would take up to three days. The integrated approach using data exchange took a total of three hours. Thus, providing that relevant data can be directly instantiated at the same time as the spatial and building fabric layout is being prepared, the savings for such a complex process can be immense. The above test indicated 90% time saving.

This may be overstating the case; however, it appears reasonable to suggest that 50% is easily achievable and 75% is a definite possibility.

Conclusions

One of the most important conclusions drawn by van Tienhoven in looking at STEP is that, to ensure maximum benefits from the application of standards, their application needs to be part of a business improvement strategy. This conclusion is in complete agreement with the conclusions which have been drawn within the CALS community where business improvement has become the focus and the development of standards is a means to support this focus.

Work undertaken on integrating applications directly has demonstrated the level of benefit which can be achieved even between specific software applications. Generally, these benefits are significantly greater than those which accrue from automating manual processes by computer. It is reasonable to extrapolate those benefits into a scenario where *most* software is able to work together collaboratively.

More enlightened contractors and clients are beginning to see the potential of standards development in the application of product model and object model based technology and are prepared to back up their vision with effort. It is interesting to note that effort is coming from these quarters since analysis of construction industry output suggests that these will exhibit the greatest benefit on an industry wide basis.

However, most models developed to date have been concerned with design and such models can have significant business benefit due to their continuing impact at later project stages. It is in the boundaries between disciplines and between project stages where the greatest benefit of standards development may be expected.

In the UK, the Latham report called for a 30% improvement in building construction processes without necessarily being too specific as to which processes would contribute what to the total. It is reasonable to assume that a significant part of the improvement could result from the widespread introduction of product and object model based technologies to the industry and to the use of product model and object based information exchange and sharing. Whilst it is not possible to be precise with regard to figures since there is no supporting project based evidence, it would seem probable that a contribution of 3% - 5% improvement could result directly from a widespread adoption of a mature technology. Structural changes resulting from this adoption could contribute at least equally if not more.

This paper has presented a significant proportion of the information available on the business benefit of applying standards for information exchange and sharing in building construction. The evidence available suggests that there is a very real and significant benefit which can be obtained in and between all disciplines and within and between project stages. There is still not enough hard evidence or sufficient coming from real projects. More evidence is needed to fully convince industry to continue to support the development of the required technology and the standards which will provide the benefit. To repeat the words of Andrew Crowley quoted in the introduction:-

“A common complaint heard from academics and software vendors is that those involved in the construction industry are resistant to change. I feel that this does a disservice to many professional people who are not so much “luddite” as realists. They will not take on technology because it is new, but because it is beneficial.”

It is necessary to continue work on development of the technology and the models required by the technology and it is concluded that continued support for the STEP/IFC based approaches is the best way to do this.

However, the primary conclusion is that there needs to be a significant study of the financial and time benefits available from adoption of the technology and of what structural changes may be appropriate to release the benefit. Ultimately, only evidence of this nature will convince business leaders that they must embrace and support the use and development of standards for information exchange and sharing.