

Maximising the Benefits from IT Integration for Architectural Project Documentation

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ABSTRACT

The development of Information Technology is traced. The impact of this on the communication processes of the AEC industry is noted.

The paper identifies current trends and imminent developments. Out of this it projects some of the options that might be regarded as feasible, likely, and safe to assume.

It suggests that present technology and imminent technology have reached the stage in which a fundamental shift in the methods used for architectural project design and documentation is already occurring. This has created a major dilemma for designers and project managers. It is suggested that there is no middle ground or evolutionary choice and the paper warns of the practical consequences of an ill planned transition.

It presents a strategy for maximising the benefits in the production of architectural communication and project documentation through the use of IT.

Key Words

information technology; transition; trends; development; strategy

The Use of IT by the AEC Industry

It is hard to conceive of any task or problem that individuals in the construction industry face each day which does not involve the retrieval, processing, communication, and the storage of information. Indeed, that which the majority in the industry call "work", is mainly about "information handling".

Even tradesmen and labourers on the job spend much of their time giving, receiving and finding information about the work they are to do, and the materials to use. Designers, technicians and middle managers spend most of their time processing information. The chief executive officer, director, principle designer, architect, engineer, quantity surveyor, financial manager, spend almost all their time with the analysis and flow of information. It is widely acknowledged that the success of a business depends on the communication of information. A key activity in this process is the preparation of graphical and textual documents which detail the architecture and engineering of the building.



The construction industry, like every other industry today, is constantly offered more and more amazing technological hardware and software to carry out all manner of these tasks involving the handling of information in all its forms.

However, repeatedly we see surveys (CICA, 1992, et al) and reports in the professional magazines and journals around the world, which indicate that the majority of those people who work in the construction industry do not use anywhere near the potential of the IT systems at their disposal. Nor do they use them efficiently. There are cases reported where businesses have failed, supposedly because of information technology that did not fulfil its promise.

Stevens (Stevens, 1991) gives a critical account of the actual use by architects. He suggests for the majority of users one of the main motivations for using IT is to impress clients rather than any belief that it improves the design process. Small and medium sized firms have used computers primarily to automate the mundane but essential functions such as specification writing while larger firms have used them to automate the documentation process.

Most disturbing is the indication that the more senior an individual is in an organisation, the less working knowledge is that individual likely to have of the information technology on which the organisation has invested and intends to depend on. In the recent past the CEOs, partners, and senior managers of good design and construction businesses would have all had a good working knowledge of the information technology used in their organisation. They would know in detail how subordinates carried out their tasks, what they needed in order to be efficient, and what tasks were critical to success or failure. Today, success is very much dependent upon the correct selection and use of information technology. But many senior managers are unfamiliar and uneasy even with technology such as word processors and spreadsheet applications that have been common for more than ten years. If asked "What is CAD?", too many are likely to respond "That's computer draughting, isn't it?". No wonder the most successful use of computers has been for specification writing.

It is easy for those who have embraced IT from its early days, and for some who have recently graduated, to assume everyone knows how to use IT and that they do in fact work with IT. It is useful to remind ourselves what it was like for the majority just twenty years ago; ten years ago; even five years ago.

Twenty years ago, modern Information Technology was an IBM golf ball electric typewriter for the secretary/typing pool. Engineers were well equipped if they had a programmable calculator. Graphics technology was "Letteraset" and stencilling templates used by draughting staff equipped with "modern" track drawing machines. Diazo printing and microfilm set the standards for graphics technology. Telex was a common means of business communication and if you didn't have telex there was always telegraph for hand delivery of things such as late contract bids. Industry communication techniques that had evolved slowly for over one hundred years, and were the norm. Quite suddenly these began to show signs of strain.

Ten years ago, the dedicated word processing computers had come and already were on their way out. The IBM-PC was one year old and causing concern to computing professionals because users could by-pass them for many of their engineering tasks. Micro computer manufacturers predicted "one on every desk soon"! Various xerographic techniques for plan reproduction were in vogue. The largest professional offices still had main-frame computer

departments and a few even had a CAD workstation or two. The mid-sized office might have had a mini-computer, but the main computing task for it was likely to be "keeping the books". To do real engineering design you still needed a link to a bureau main-frame. The industry had no FAX machines or Cell Phones.

Five years ago, the micro-computer revolution was well underway. The new buzz word was "Information Technology" (IT) for everyone. Laser and bubble jet printing made desk-top-publishing a reality (or nearly so). For graphics on larger media, wet pen plotters were still best. Suddenly CAD seemed within the reach of almost everyone in the industry and was becoming more so every day. But was the industry ready for CAD?

Although much of what we now accept as normal IT was predicted by researchers more than twenty years ago, the reality of some potentially very useful IT and affordable IT has only just arrived. For most of us it is very, very new. Unfortunately, the construction industry has squandered an opportunity over the past twenty years to implement industry wide systems of data coordination for manual methods. This would have been a good spring board for doing even better things with the electronic information technology we now have. Some would say that we do not need the disciplines which were suggested twenty years ago. It is said the industry should and does do things differently. With the power of IT available today you can search and find the information wherever it is and however it is structured. These statements are misleading and not supported by reality. The evidence suggests that the more sophisticated IT becomes the more important are the fundamental disciplines which have been sadly neglected.

Criteria for Construction Modelling in CAD

Information Technology has always offered researchers a dream that by using IT tools, users would be much more productive than they could ever be using traditional means. Various models have been proposed, but they all had aims more or less as follows:

IT should permit the creation and early detailed analysis of many alternative design proposals rather than just one outline proposal.

IT should enable the selected proposal to be fully documented and priced in quick time.

IT should enable changes to be incorporated easily. For the construction to be planned and executed in quick time and at minimum cost.

IT should assist in managing and maintaining the facility during its effective life.

Until very recently the computing technology affordable by the majority of firms was underpowered and the operating systems juvenile. It could not fully deliver what was promised. This is no longer the case. The challenge now is to actually apply this power in the smartest possible way and realise its profitable use. Stoker (Stoker, 1991) provides a good maxim: "The most successful firms have redefined productivity as the avoidance of work. While it is good to be able to perform a manual task 10-20% faster, it is better to not do it at

all." This was a reference to using IT that implied the work was about the creation of 2D graphics, but it is useful to bear this rule in mind in other contexts as well.

There will be more than one strategy needed in working smarter because no one organisation will be able to communicate the vision, let alone convince, every associated player in the construction process. Nevertheless, it will be important to know what goals an organisation is striving for, and what will hinder the achievement of these goals. This paper cannot address every area of the construction process. Nor can it address the options of every player in these processes. Hence the discussion is focussed more on the architectural project documentation process.

For those whose aim is to maximise profitability, a number of imperatives have already been alluded to. At the implementation phase of design and documentation the goals will be achieved through removal of uncertainty in the following areas:

- Striving for integration of all processes.
This will require agreement on the definition of data structures.
- Avoiding duplication of data.
Unnecessary duplication is a major danger in more ways than one.
- Avoiding un-necessary detail.
Apart from the wasted effort in producing it, the redundant data also creates potential confusion. Knowledge of standards is important here.
- Ensuring all necessary detail is available.
This requires that all information is actually complete.
- Being aware of each end-user's needs.
Means the provision of data by the appropriate selection & sortation for a defined end use.
- Common language
This involves discipline in the use of agreed classification & procedural conventions.
IT can help with this.
- Certification of minimum agreed documentation standards.
This should be automated through IT.
- Clear demarcation of roles.
Making sure it is clear as to who does what, when, and the areas of role overlap.
- Acknowledgement of inter-dependencies.
Explicit understanding on all sides of every interdependency and the consequences of these.

It is suggested that the most important key to achieving this will be via a 3 dimensional database for the graphical model of the construction which is dynamically linked to any

number of associated relational databases. The ease with which the 3D database can be created, modified, and manipulated assumes critical importance. No longer is this goal hindered by the limitations of affordable information technology. 3D model creation has only very recently become a realistic proposition for the majority of designers and it may still be some time before there is general acceptance of it.

There are commercial software products available which aid the conception, prediction of performance, detail design generation and photo-realistic visualisation, of all elements of the 3D building model. Until recently one of their greatest limitations has been the handling of variations in the form of additions and deletions to the model. However this is improving all the time.

Another major draw-back for off the shelf software is the necessity for them to invent conventions and procedures. Often the existing methods of the industry are inadequate and often inappropriate because they were designed for an age which assumed 2 dimensional media. The rigid application of these immediately forces un-necessary redundancy into the data model and imposes restrictions that are not helpful. One small example: It has been common for drawing standards to specify the minimum text height and style in order to suit micro-filming. A similar assumption has dictated line thickness and black/white contrast. All of these can be relaxed if the assumption of micro-film standards that were appropriate in the 1960's is removed. Text may be smaller while still being legible and indelible. Line thickness and color may now be used much more freely than before. This all enhances communication.

Downstream processes are also becoming very sophisticated. The use of associated relational databases permits more than just the automatic generation of specifications and bills of materials. Direct and dynamic linkage between these databases and the graphical database permit very fast and powerful estimating and bidding systems to be a reality. These are being linked into building product supplier databases that provide current price, availability, delivery requirements, etc. It is also possible to automatically generate the construction project management network programme as well as many other management tasks that previously consumed considerable resources and time.

Expert systems are already being applied in the determination of criteria from regulation and legislative control documents. There is still work to be done in making this interface seamless with other information technology tools used for design.

The multiple presentation model described by Eastman (Eastman, 1991) is being applied in a pragmatic and useful way on affordable microcomputers. It is now possible for the database to intelligently select a real object representation or a symbolic abstraction to suit different views, scales or other schematic requirements of the model. There is no suggestion that one should attempt to prepare a complete solid model of the building down to the finest detail.

Eastman also established a good set of criteria for the selection of a CAD system based upon its support for building modelling. Eastman's criteria are worth para-phrasing here.

A CAD system should have:

- 1 Ability to dynamically generate multiple 2D presentations from 3D model.

- 2 Support for user defined objects.
- 3 Support for graphic editing of object presentations or substitution of 2D annotated views as a substitute for 3D views.
- 4 Means to automatically update custom presentations of objects when one of their parameters change.
- 5 Automatic presentation control for the extraction of attributes.
- 6 The facility to define views in paper-space and control scale separately between paper space and model space objects.
- 7 A hierarchical support structure for objects.
- 8 Support for the definition of rules for automatic maintenance of aggregate descriptions both graphical and attribute.
- 9 A user interface to allow views to be generated incrementally, without the need for the user to manage all views in an object-centred manner.
- 10 Support for parametrised objects based on external variables.
- 11 Support for global definition of lines and surfaces that can be used to parametrise locations, shapes and properties of objects; retain global parameters permanently.

In 1990/1991, Eastman could not find any system that meet all the above criteria. Two years later there are systems that come very close and they are affordable.

The major problem remaining for the construction industry is that there is little agreement on detail specification at the software level for many of these criteria. Conventions are still ill defined, missing entirely, or not agreed within the industry. It is naive to expect that the industry will reach agreement in the short term. There are still many in the industry who are largely unaware or unconvinced that a problem exists. This is in spite of repeated studies, commissions, reports and conferences that have given warnings and recommendations since the 1960's.

This creates a real dilemma for those who accept that information technology is now able to deliver the economies it promised. If all those involved in the industry today are to realise the full potential value of their investment in IT they will need to adopt industry wide data coordination conventions and standards. However, there is a good chance that the majority will never achieve such agreement. It remains to be seen if this conference will be able to mark a change of direction.

Strategy for Maximising Profit from IT

So how then should an organisation operate so as to maximise its IT investment? Any strategy needs to accept the reality of the world today:

1 Accept that many in the industry will continue to be slow and un-willing to adopt IT for whatever reason. Do not attempt to change those who do not want to change. Devise a strategy for dealing with these organisations because you may be forced to do so. You do not want to let an organisation that operates on a different plane, hinder your use of the technology you have invested in.

2 Beware of those who think they do use IT, but are not prepared to commit themselves and their organisation to the full consequences of this decision. Dealing with them could lead to a major disaster for you both. Therefore have a different strategy for this case. This concerns agreement on the most fundamental approaches to the use of IT - eg, whether or not you will both be working on a 3D model or a 2D model of the database.

3 Beware of the "Luddites" who may infiltrate or already exist in your organisation. You may not only be prevented from achieving your goal of profitability, but be destroyed in the process. On the other hand, foster, reward, and be a champion to those on your staff who are enthusiastic for "the cause". They will always give more than they receive.

4 Look for like-minded associates and maybe even competitors. It is possible to obtain mutual gain between competitors. The preparation and adoption of defacto standards is a case in point. Be prepared to assist and share knowledge with like-minded associates and competitors. On the frontier of IT knowledge no one knows all the dangers you may confront. It's all very new. Don't, however, become a crusader for an industry cause - your motives will always be questioned. Leave industry causes to independent industry organisations and associations.

5 Be very clear on what your philosophy is for the use of IT. This will be reflected in the documentation of office conventions and the standards you follow. Simply owning IT will not make you profitable.

6 Do not skimp on continuing education. The cost of ten IT seminars or courses is still likely to be less than one mistake you might have avoided from education. One mistake could be fatal.

7 Accept that technology will continue to advance at a rapid pace. Plan for upgrading hardware and software in tandem with your associates. Prepare a policy to dispose of obsolete hardware and software. Have an annual contingency budget for that very attractive IT item you discover and could not have planned for. Spend it wisely.

Planning for Future Developments in Information Technology

Some of the more important technology developments that need to be acknowledged and planned for include:

1 Development of the IT engine:

Micro processor technology shows no sign yet of levelling off. Computing power has been doubling every 18 months for the last thirty years and this trend continues. It is certain that extremely powerful computer systems will be affordable by anyone. Un-dreamt of power a few years ago now seems likely within the next three to five years. A recent report (Cline, 1992) on the fifth annual Microprocessor Forum 1992 mentioned that all speakers agreed that the fundamental limits of physics won't become an obstacle for processors at least until the end of this decade.

2 Multi-processing chips vs Multi-threaded operating systems:

Although commercial multiprocessor PCs will exist in the Intel P5, Motorola 68060, and Sun Sparc-9, few chip makers think there is much advantage in a chip being able to execute more than four instructions simultaneously. Rather, they will be looking to multi-threaded operating systems such as Windows NT to control several central processors at one time. This offers enormous power even over what is now considered to be incredible. With this power, many new functions become feasible.

3 Mass digital storage:

Digital storage capacity and retrieval techniques are also developing fast while prices are tumbling. For many of us we need to redefine what is regarded to be a large file.

4 Telecommunication:

Another major development is in broadband communication. At some stage, communication channels will have enough bandwidth to saturate all the human senses. 100 megabits/second will do it and this could be available soon.

5 Computer aided manufacturing:

CAD/CAM still has much promise in the building industry. With the power of IT realised, there should be little justifiable difference in the cost of a bespoke component versus a mass produced product. How will this change our approach to design?

6 The Computer/Human Interface:

Although much work is in the pipeline, there does not appear yet to be anything that could be said will result in a revolution. The new pen based technology, voice input, stereo LCD screens, head/eye motion devices, and holograms all have their place but are unlikely to replace the QWERTY keyboard as some have suggested.

Need for New Strategies

If we are to accept that much of the technology referred to above is here now, and given that it has only very recently become affordable to the mass market, the realisation is that the new paradigm for design and construction has arrived. This has created a major dilemma for existing designers and project managers.

Many in the construction industry have not realised the potential which exists with IT. Nor is the industry suddenly going to embrace IT or attempt to discover its true potential. The logistics of educating an industry in what are fundamental changes inevitable mean long term strategies are required. Should (can) we restrain the trail blazing IT leaders while the majority of the industry becomes educated? The gap between the leaders in IT and the majority of the industry is extending all the time.

One major shift that will take a concerted effort to be generally accepted, is the preference for creating an integrated 3d model database of the construction from the start. Apart from needing the appropriate hardware and software that will enable the creation of such databases, it is even more vital to have knowledge and experience in working this way. There is much to know, and discipline to apply, if the result is to be successful.

This is not to suggest that traditional 2D presentation media and techniques are redundant, only that they become a by-product rather than "the product model". For many of those in the industry today this is very threatening. Firstly because they are skeptical that it is possible, and secondly because it debases and changes the priority for certain technical skills that previously were very important. New skills and disciplines will have to be learnt rapidly if one is to continue to be employable.

The next realisation is that transition from old ways to new ways is fraught with many difficulties. How the transition is handled can be an expensive and dangerous time for an organisation. In many aspects there is no middle ground where two methods can co-exist in sympathy with each other. It seems better to make a clean break with the past, and all its baggage, which could result in neither being profitable. But is it realistic to expect to be able to almost overnight put together a team and the IT tools they will use, and expect them to be up and running efficiently?

A strategic plan for change is extremely important, and having the right mix of experienced managers and operators essential.

As referred to above, an organisation on its own cannot dictate to everyone in the industry their ways of working. A strategy for a mixed mode of operation with traditional associates will still be needed for some aspects of the process.

Every organisation will need to clarify its understanding of "the product model" concept for building. It is important that those who see the building model as a problem of knowledge representation in a data model, need to be reconciled with those who see it as a problem of object classification.

With a workable product model for building it would then be possible to concentrate on achieving integration of process and relation of data. Hopefully there will be continuing support for the concept of shareware when it comes to providing tools to make this work.

Conclusion

The main message to the industry is that we must vigorously strive for agreement on IT conventions and standards. The benefits of such agreement are enormous for all sizes of organisation.

One of the most heartening things about IT is its potential for enabling the participation of individuals and smaller firms in much larger projects than was feasible in earlier times.

With IT there are so many overlapping requirements and so many new possibilities that no one person can ever be expert in more than a one or two. Hence there is plenty of scope for specialisation and entrepreneurial activity.

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