BENEFITS OF DATA INTEGRATION IN BUILDING MODELLING: 3D OBJECT ORIENTED PROFESSIONAL COLLA-BORATION

AUTHORS

Kokosalakis Jen
Liverpool John Moores University and School of Built Environment
Clarence Street, Liverpool, L3 5UZ, UK
j.kokosalakis@livjm.ac.uk
Hohmann L.M.
'The User Group' Chair
lmh@globalnet.co.uk
Pamplin I., et al.
'The User Group' Secretary
ian@pamplinass.source.co.uk

ABSTRACT

This paper will review current progress across the building construction industry in meeting demands for use of data integration with the 3D building model as the coordinating device in building design and development. Decades of national initiatives from NEDO (1990) to Egan (1998) have striven to encourage collaboration in first the building design team and later targetting in programmas the means to accomplish this. In its 14th year 'The User Group' has intensified efforts to persuade the industry of the benefits of associating all data involved from the first briefing and conception of design needs and ideas, through the development of the design, testing for structures, costs, heating, lighting, urban and rural environmental impact, facilities management, adaptation and even the eventual controlled demolition of the building. Examples in this paper will be reported from 'The User Group' conference, "Profit from Data Integration: An industry update", (NEC, Birmingham, Nov. 1998), to indicate how various organisations are now profiting from data integration in 3D object orientated modelling.

BENEFITS OF DATA INTEGRATION IN BUILDING MODELLING:
3D OBJECT ORIENTED PROFESSIONAL COLLABORATION

Introduction

This paper seeks to extend efforts towards encouraging our construction industry to become more efficient, competitive, responsive and accountable. Research shows a limited number of model companies and even small practices are benefiting from reorganisation and resourcing to centre the 3D object orientated CAD building model as the key building database to coordinate decisions by all those parties involved in the design decision making process. Together with co-members of the organising committee of 'The User Group' I have headhunted spokespersons for such exemplary organisations to bring together a series of presentations at their 14th Annual Conference. This was held at the NEC Birmingham on 27th November 1998. Members of 'The User Group' are dedicated to the use of object-orientated 3D CAAD design tools, particularly in the area of the integration of building data and building models and increasing interoperability. It evolved from the independent user group of the DEC- and Prime based RUCAPS/Autoprod building modelling software developed by the GMW Partnership in the 1970's, and expanded to include t2 Sonata in the 1980's and latterly Reflex, ArchiCAD and Architrion and is open to other like minded products and users. 'The User Group' functions combine application specific discussions with presentations on developments in the building industry as a whole and wider issues. This year's conference theme was **"Profit from Data Integration: an Industry Update".** Senior members of organisations were invited particularly to attend and be convinced by these progressive implementations of software centred organisation of building processes. Delegates were challenged: "Are you still using CAD systems only for producing 2D drawings and 3D perspectives? Come and see what has been achieved through intelligent solid modelling in the construction industry. The conference highlit the use of Solid Modelling with object oriented data bases within the construction industry, displaying through presentation and demonstration the profitability already achieved from the use of integrated software solutions and charting the way forward." Since the contributions were considered to be very significant and important to promote to the industry and there appears to be no tradition of published proceedings, it was agreed that I should report the substance of this conference to AVOCAAD to assist in the dissemination of developing good practice.

The areas offering opportunities for greatest 'profit'

from the application of CAD to the building process, frequently identified during the presentations to 'The User Group' conference—" Profit from Data Integration" proved to fall in three main sections:

- **Firstly**, in <u>early conceptual design</u>: (If the client can understand the architects' ideas at an early stage, it is possible to avoid persistence of misunderstandings progressing to the point, where redesign is too lengthy and costly and the client remains dissatisfied, or pays an outrageous figure).

- **Secondly**, if all groups involved in design and delivery of the building, are working on a single model, or an associated series of models, (to which all data is input and from which all data is output); it is possible to coordinate all the activities and decisions, to simulate and test reliably. This can achieve a more streamlined process, avoid conflicting information, ensure attainment of objective criteria, result in quality design which reflects the clients' and designers' ideals *and save costs.*
- **Thirdly,** integration of data on specified components within the 3D object orientated CAD model, leading to reliable takeoffs, can avoid the tremendous, costly, labour hold ups—(which could have been inevitable if poorly defined specifications had to be worked out on site).

'The User Group' intends to continue to press all members of the industry to *strive to push the boundaries* of research, teaching and experience forward, particularly in these notoriously destructive areas. My research seeks to identify, capture for explanation and publish good practice in these activities for explanation to students, academics and practitioners. This paper is planned to form part of this effort, by seeking to extract the key analytical, prognostic and prescriptive ideas and practice presented by the following contributors. The resumes in quotes are headed by presenters' themes, names and associations and constitute extracts from these contributors' full presentations to the conference. They are followed by my comment on each, in sequence, reviewing their contribution to the overall theme. I should point out that these comments are not those of the contributors. They are only my opinion, or my interpretation of parts of their fuller presentation and I welcome any challenges. For the full materials, readers should contact the contributors direct, (see footnotes), or access the WebSite—(http://user-group.biw.co.uk).
I have felt it useful to precede the said series of conference extracts with the following two sections, which I consider important to set the scene.

Recent commentaries on this theme

Following a long line of advisory reports, Egan, (1998) has suggested "enormous benefits are to be gained in terms of eliminating waste and rework . . . from using modern CAD technology to prototype buildings and rapidly exchanging information on design changes". The UK Construction Minister, Nick Raynsford (regarding the role that technology has to play) stated (Gardner, 1998) "opportunities on offer include better client briefing and design management through 3D visualisation and company wide knowledge banks. More accurate costings, fewer errors and less litigation should follow, resulting in cheaper, high quality facilities that meet the client's need and ensure greater profits for construction companies". Carney, IT Director at contractor Costain was also quoted by Gardner—"3D modelling and the use of a single model for the entire life of a project is streamlining the process. There are three key words in IT at the moment integrate, integrate and integrate. Software developers have responded by developing object oriented 3D CAD packages." Also at Buro Happold, "individuals and design teams are able to harness the knowledge of their entire firm." Mark Nellis is cited (Doyle, 1999) as saying, "If you computerise your drawings then you get a 20% cost saving and if you computerise your company processes, then you get efficiency gains of 1,000%. . . .The research and development budget of UK construction is absolutely tiny compared with other countries. Architects have a problem spending their own money but seem to spend other people's like water!" CICA

(op. cit.) suggest that “expenditure on IT among architects averages 4-5% of practice turnover each year. . . ranging from 3% to 10% among the larger practices.”
Pleasing signs of progress include: (Fairs,1999) announced that the RIBA have commissioned a Future Studies Committee to “carry out ground breaking research aimed at quantifying the economic benefits of good architecture, particularly investigating whether it “produces clear commercial benefits for clients.” Fairs quotes RIBA’s Chris Palmer as citing good practice examples of “Evans & Shalev’s Tate Gallery, St Ives’ economic gains for the area”, while Bennetts Associates’ 1994 PowerGen Office HQ, Coventry had generated tangible benefits for the client”. Although the latter quotation is exemplarily pertinent to the discussion, I find it irresistible to wonder whether the implication is that it is unusual for architects to design benefits for the client!

Government and industry: a brief critique of poor research base and reform

A seesaw of buck passing seems to have persisted through recent history between the construction industry and government-led committees. I must attribute credit here to Crotty whose presentation at ‘The User Group’ conference, (reviewed here) laid a challenge that there had been a failure to pursue in-depth research and development into the underlying causes of problems in the UK construction industry, including the sequence of government committee reports. He does appear to be right in this analysis. Time and again committees set up by UK Government appear to rely mainly on their own expertise and not carrying out actual research into organisational processes and relationships. [Although the earlier report—(Emmerson, 1962) is described as a ‘Survey of Problems in the Construction Industry’]. (EDCB, 1967) remarked that “the Banwell committee’s recommendations and conclusions (Banwell, 1964) were not always specific or precise”. However they (EDCB), at least considered that in the complex relationships of the construction industry . . . involving clients of all kinds as well as contractors, operatives and professional men . . . no prescription can be right for all time for an industry in which the pattern of these relationships is bound to evolve.” however they considered that although the Ministry of Building and Public Works did not accept the Banwell report’s recommendation that they should confer with all the interests to achieve the “necessary coordination”, it is “*up to the industry not the Government to create a body to do this.“* It is interesting that (EDBC,1967) sought to reduce “the incidence of variations, which “ . . . would benefit . . . “the productivity of the industry”, yet they laid many problems of delays on the client’s “lack of decision or late decision”, “or changing his mind”, or not having “briefed the architect properly about his requirements” and even the contractor is charged that he “may not have asked for detailed information early enough”. This attitude of blaming every one else does not indicate a mature organisation capable of objectively conducting self appraisal and transformation! Again (EDBC, 1967) remarked, “One common characteristic of almost all variations is that there has been insufficient forethought before starting work on site.” Yet their solution seemed to be for the client to pay for his “misdemeanour” and for the builder to take responsibility for their own “explicit programmes for their work”. After over three decades, it is very disturbing to find the same problems being reiterated,

but this may not be surprising when we consider how little real onus has in reality been placed on the industry to reform.
(Nicholson, 1998) suggested that (Latham, 1994) (a little more analytically), "advocated a process-oriented team approach and a belief in the ethic of fair trading" but failed to understand the "value of good design or the iterative nature of the design process". Since the Latham Report does not cite much in the way of original research, it is hardly surprising! Latham did demand a 30% improvement in productivity, yet is criticised by Egan, (1999), that it did not establish any means to measure the improvements. At least Egan has said it would "like to see" set in place a number of processes:
—the construction industry produce its own structure of objective performance measures agreed with clients
—sharing of comparative performance data with clients and between companies
—benchmark comparative success through the employment of company "score cards" to measure "progress towards objectives and targets" for predictability, cost, time and quality, based on performance indicators.
Again Egan (1999) seems to have followed the same track, i.e. a selection of esteemed individuals were asked to meet and address a number of terms of reference. The difference might be that their membership and expertise included transformed construction organisations *and in particular, people from other industries which had already successfully transformed*. They did draw on research and did suggest specific areas for new research, including a £500m programme for demonstration projects and a publicly accessible "Knowledge Centre" based on the DETR Best Practice Programme data. So, the latest round of investigations appears to recruit the companies of best practice, but will this exclude opportunities for clients to challenge with evidence of the need for further reform?

Why Modelling is Crucial to Industry Improvement—Ray Crotty, C3Systems [1]

The analysis

"Relationships in construction are as they are for a number of very good reasons. They don't arise simply because the industry is populated by short-sighted egoists. They arise ultimately from two fundamental and currently inescapable causes:
the lack of tools with which to communicate conceptual design ideas to lay clients, and
the lack of tools with which to communicate the detailed design amongst the professional team and between them and the construction team.
Modern buildings are enormously complex products and the project teams required to construct them are correspondingly complex. These teams generate huge volumes of highly complex information which must be communicated accurately, completely and quickly to the large numbers of participating firms.
It is the mismatch between this enormous communications problem and the tools available to deal with it that gives rise to most of the apparently dysfunctional culture and behaviours observed in the industry. The remarkable

[1]Ray Crotty Managing Director of C3Systems raycrotty@c3systems.co.uk

thing about construction is not that the industry performs badly. The truly remarkable thing is that, in the face of the complexity of its products and processes, it succeeds so often in producing buildings that delight its customers and genuinely enhance the environment.

The way forward

The attitudes and culture of the industry are those which are necessary to survive in the face of the mismatch between the complexity of the information we work with and the tools available to carry out this work effectively. To be more specific, they are the attributes necessary to cope with the confused, opaque manner in which project information is managed and communicated using the tools and techniques currently available. *Perhaps the key point is that culture and attitudes are not, in themselves, causes; they are the effects of these more fundamental underlying problems.* To focus on them, as Latham (1994) and Egan (1999) have done, while laudable, is not likely in itself to generate lasting change. The underlying causes must also be acknowledged, confronted and dealt with as effectively as possible.

3D Object based modelling systems provide the most promising means of overcoming these underlying problems. They should enable designers to produce 'What you see is what you get' conceptual designs and 'What you see is what you've got to build' detailed designs. Allied with pervasive broadband networks, models of this type will transform the operation and behaviour of the industry.

The Industry must stand by this vision and must become more active in the work necessary to realise it. This means contributing actively to the promulgation of classification systems like Uniclass and the Common Arrangement. It means persuading designers, particularly architects, to understand that they must take more responsibility for the overall information strategies of the projects on which they work. It also means persuading the industry's educational institutions to incorporate information management as a core discipline in all of their programmes."

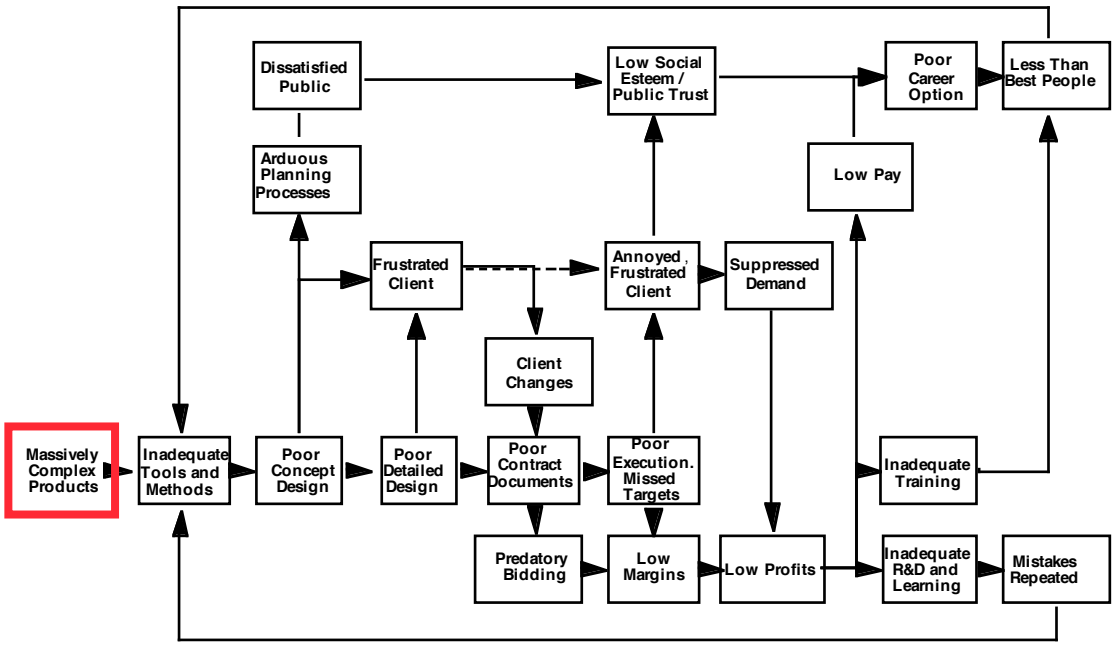


Figure 1: Analysis of Today's Dysfunctional Industry © Ray Crotty C3 Systems Ltd . 'Profit from Data Integration,'—The User Group.

Comment

Crotty presented a very clear analysis of the very complex and interrelated problems in the Construction Industry and the path to be followed to resolve them. Through his diagram above, he showed the interrelationship between technological development in practice and education and how important it is for research to investigate solutions to handle the complexities of the processes, to provide better implementation of full 3D modelling systems and to improve and develop tools particularly in the key areas of concept design and detailed design, including contract documents. The impact on the client is apparent. In his fuller conference presentation, he eminently explained why the stages identified are all executed "**poor**"ly, but could benefit from new technology, to ensure all parties are better informed of each other's ideas and so progress more effectively, speedily and with greater economy and quality. Those elements of the industry, who do not respond to the need for transformation, will perpetuate poor performance, (and poor quality achievers) and eventually will not be able to compete.

He pleaded with 'The User Group' to keep the "Focus on Geometry", the pressure on the International Alliance for Interoperability and charged everyone to "keep the faith". This drive should be extended to the wider national and international community hopefully, through this paper and the activities of AVOCAAD and other such proactive groups.

Crotty concluded by suggesting that the way forward for "'No Limits' IT in Construction" lies in such technological developments as Concept Models for Visualisation, Detail Models as Engineering Prototypes, Pervasive Broadband Network services and Online Models and Repositories. Industry Actions should concentrate on improving the Classification Systems (e.g. International Association for Interoperability), the Behaviour of Networked Enterprises, Education and Research. Relevant Research and Development to inform training, education and learning are vital to reverse this downward spiral. Crotty felt that UK government committee reports had not been based in deep investigative research into the structure and causes of failure of the building process. Rather, reference to these documents sees from Emmerson (1962) through to Egan, (1998), advisors and members of the professions being called together to share their expert opinions.

To summarise, Crotty's main points were the complexity of the building teams, processes, information and products is not matched by an understanding from those involved, or effective tools. We should focus on the causes of the problems not on the effects. Information strategies based on 3D object based modelling provide the most promising means.

Sonata Special Interest Group address: Software Tools— Solid Modelling Future

Sonata Development, News and Future Developments—Nick Nisbet, Alan Jacobs, George Stevenson, Advanced Visual Technologies [2]

[2] Nick Nisbet, Alan Jacobs, George Stevenson, Advanced Visual Technology Ltd, n.nisbet@biw.co.uk

"RUCAPS grew from being specifically developed for the Rhiyad University development to become a general purpose building modelling tool using plan, 2.5 and 3-D representations. **Sonata** introduced a broader and worldwide membership including many building services users and an increasing number of retailers. The recent inclusion of PC based products has broadened the membership yet further.
Visual Technology, the developers of Sonata reported the steady interest in the product: major users such as HBG Kyle Stewart, Alfred McAlpine and Target, the Australian retail group had all invested in the installations. The program of annual updates to the application was continuing, with HTML and VRML support being delivered across the user base this year, and next March's release was previewed. Visual Technology also reported on their involvement with several major industry initiatives on 'Partnering', on industry standard component databases and the IAI. The continued vigorous growth of the retail sector meant that the company was attracting further investment to support continued growth. In the break-out session the users were able to report on their experiences and project workload and evaluate how the new releases would enhance their productivity.**"**

Comment
In private, Sonata users were privileged to hear of further developments and successful client applications.

ArchiCAD Special Interest Group addresses:

A working view: Property Objects—Steve Hendry and Richard Vertigan, Taylor Woodrow [3]

An aim of Object Modelling
One of the ultimate aims of an 'Object' Model is to have the ability to be able to create any structure or set of components within the computer and have the ability to schedule off all the individual units and assigned data.

ArchiCAD
The Graphisoft Modelling Tool—ArchiCAD has the ability to assign data to objects using the Properties functionality. This feature allows user defined attributes to be held within any Object used in an ArchiCAD model or be attached to another Object as an Object in its own right. The information could be Specification data, part numbers, design information or costing information, in fact anything that can be written in a text file.

Practical uses: Gatehouse
Taylor Woodrow (TW) have used the Properties functionality of ArchiCAD on previous projects as demonstrated at the User Group Conference, with the GateHouse project. This project was modelled to a higher level of detail than is usually carried out on most projects. It even included the addition of objects to represent reinforcing bars in the foundations of the structure. This allowed the scheduling (Bill of Quantities) to be extracted to a much greater detail than usual. However the benefit of using Property Objects is that the model doesn't have to be modelled to a higher detail level. The properties required for

[3] Steve Hendry and Richard Vertigan, Taylor Woodrow Construction Ltd. Europe (Building) Division, steve.hendry@taywood.co.uk

scheduling could be held in their own object and simply applied to a structural element.

Gatwick Airport
TW are currently working with BAA to extend the South Terminal departures lounge. To aid with the design and site management a 3D Computer Model is being developed using various tools including ArchiCAD version 6.0. The design is intended to be based on Component Design. This means that the manufacturers' standard components are used wherever possible in the design of the structure. i.e. The design is more manufacturer driven than usual. Non traditional methods of incorporating the mechanical and electrical services within the structural elements are also being developed.
The ability to include all relevant information within the model should prove to be a great benefit. It is intended that the data contained within the model will be used to coordinate all of the design disciplines. The model already provides the ability to schedule off the steelwork members with their correct properties. This allows easier checking of the consultant's design and the fabricators' information. As the model develops the continuity between the various disciplines can be checked and any extra information assigned to elements could be a benefit later on, e.g. suppliers' details and part numbers assigned to light fittings can be of benefit when constructing the project and on completion if used as a Facilities Management tool.

Future
It is already possible to create an Object Model with assigned properties, it is however quite an ordeal to input and retrieve the information. It is hoped that in the future the tools used will develop to make the process easier and quicker**"**.

Comment
Taylor Woodrow are to be congratulated on charting the implementation of the Component Data Base for ArchiCAD. Though limited data attachment has been possible with previous versions of this object based CAAD program, Version 6 has wide ranging potential. The detailed work process for Taylor Woodrow, involved creating text files from Standard Method Measurement books' takeoffs to act as Component Details attributed to objects in the model. However once Industry standard descriptions are made available as immediately compatible files, the process will be simplified. (Though each organisation will need to establish their own standards and records for details). Taylor Woodrow illustrate very clearly a function of the 3D Object Model—to coordinate data for all disciplines involved in the design and construction and specifically referring to consultancy, fabricating, supply and Facilities Management with reference to the example of steelwork scheduling.

The Future of ArchiCAD—Andras Haidekker, Graphisoft, UK [4]
How do ArchiCAD developers think about the future? The major driving force is a mission critical application responding to dependency of the team on the need for projects to have reliable functionality for the whole efficiency of

[4] Andras Haidekker, Graphisoft UK ahaidekker@graphisoft.co.uk

design. If the data is integrated we do have profit. Interoperability is essential. The system is programed to be: powerful, easy to use, reliable, stable, appealing, high tech. and affordable. We would like to serve the industry for the whole process of virtual building, in its whole life cycle. ArchiCAD began in 1984.

The drivers for development directions are:

- One of our biggest assets is that we know what people want, from our database of wishes received from the users (over 50,000), sorted by keywords.
- We consider which new technologies to build into ArchiCAD. (Over three years ago we had the foresight to build QT VR into our software).
- We have our own ideas for several new directions.

We are removing more and more geometric constraints, taking up real opportunities from internet technologies, giving importance to database links, introducing much more graphical user definition in editing parametric objects, planning much more freedom in architectural modelling and more solid modelling. ArchiCAD also now has an essential role in Product Design and Mechanical Engineering, which is even more critical and complex than architecture.

Comment
Graphisoft's concern about users' opinions is historic, dynamic and probably explains their popularity.

Partnership API products—Istvan Janasa, architect, Graphisoft, Budapest [5]
New products in various stages of marketing readiness were presented. Some are loaded from ArchiCAD and some use output from ArchiCAD. API—Application Programming Interface was developed by Graphisoft for 3rd party developers to use in association with ArchiCAD. All kinds of data can be seamlessly exported from and imported back to ArchiCAD. The ArchiCAD Presenter takes over from Playback. It is a multimedia editor tool with sound, buttons, etc. Plans can allow plotting of cameras used A media folder can be created. A comprehensive score template is used. HTML export features are planned. A new piping tool is in the Beta stage, developed by a German company. It takes exported data from ArchiCAD. The data can be processed, in typical piping controls, but including detailed joints and lists. Results can be imported back into ArchiCAD. The RoofMaker is also in the Beta phase. It simplifies the creation of complex roof structures in detail. It acts according to the particular structural component, such as rafters, trimmers, perlins, studs, posts, collar beams, etc. and it is intelligent in situations such as the the edge of roof lights, or even a curved eaves line. A new API, more sophisticated Stairmaker is also on the way. The interface routines of c++ tool API is ready and working. ArchiCAD functions with API as an architectural engine.
Gary Lawes of ArtSystems, Ltd.[6] followed and explained how the new distribution system works in the UK and the support they provide.

Comment
With these new developments added to the extended performance of the existing version 6 of ArchiCAD, which allow interoperability, component

[5] Istvan Janosa, Graphisoft Budapest, ijanasa@Graphisoft.hu
[6] Gary Lawes of Art Systems Ltd., Nottingham

database integration and fully 3D modelling on the fly, ArchiCAD has extended application for the construction industry based on its original object oriented structure.

New Drive Technologies: Backup Media and Drives—Mark Littlechild, Pioneer Uk Ltd [7]

There follow some notes from the presentation: "What is DVD? New Discs and New Hardware. DVD - Digital Versatile Disc. Very High Capacity Removable Storage Medium. Standardised by all major electronic manufacturers. Backward compatibility with CD. Will eventually replace CD-ROM drives, CD Players and Video Recorders. DVD Disc is physically similar to CD. CD and DVD discs are both 120mm diameter. CD is one disc of 1.2mm thickness. DVD is two discs of 0.6mm thickness bonded together. DVD Capacities: DVD-ROM Discs: Very High Capacity 'CD-ROM' discs, 4.7GB disc = 7 CD-ROM discs, 8.5GB disc = 13 CD-ROM discs, 9.4GB disc = 14 CD-ROM discs, 17GB disc = 26 CD-ROM discs. More choice and flexibility for software developers
DVD Categories:
DVD - Video, DVD - ROM, DVD - R, DVD - RW, DVD + RW, DVD - RAM
DVD Video: Very High Quality Digital Video & Audio. Up to 133 Mins of "Movie". 8 Sound Tracks , Different Languages. Dolby Digital Surround Sound. Available Now
DVD - ROM: Read only Memory. DVD Discs are pressed at factory. 4.7 GB, 8.5 GB, 9.4 GB, 17GB
DVD - ROM Drive: It can read CD - ROM, Photo - CD, Video - CD, CD - R, CD-RW , CD-DA. DVD - R & DVD - Video. Available Now
DVD - R: Recordable Write - Once DVD - Safe data, 3.95 GB Capacity , More than 6 Times CD-R Capacity, Compatible with DVD - ROM, Compatible with existing DVD hardware
Available now
Re Writable DVD: No standard yet set. Confusion over competing formats
Pioneer DVD - RW is the only format that can be read by other manufacturers drives
What are the Benefits to you? Huge Data storage capacity
Ability to store computer data as well as video and audio. You can still use your computer CD's on DVD ROM Players.
Where do Pioneer Fit in? Pioneer is founding member of the DVD consortium. Pioneer is chairman of the DVD working group on DVD - R, DVD - RW.
The New DVD Autochanger: DVD - ROM Version. 850 GB Capacity DVD-ROM. 395 GB Capacity DVD-R. It can read CD-ROM, CD-R. More data per disc. Investment proof - Formats have been set".

Comment

The two big differences between existing CD technology and DVD are the capacity and the data transfer rate. It is this last difference which matters for showing video and storing large computer data sets. Even though most new CD-ROM drives are fast, there are still many in use which are not fast enough for video.

[7] Mark Littlechild of Pioneer Electronics UK contact: Andrew E Wilson, AndrewEWilson@compuserve.com 01753 789735

The other advantage of DVD is that there is a standard format which can be put on to the disc which ensures that everyone will be able to play the video, and that is the DVD-Video format. This involves preparing your digitised video in the correct form, and ensuring that the file names and other details are special to DVD-Video. You will then be sure that the DVD can be played in a DVD video player, or on a properly equipped computer.
The capacity and capability of DVD is of particular interest to the design community with its tremendous increase in capacity over CD. It is reassuring to know that these formats are already available so soon.
It appears that Pioneer, the "pioneers" of the Laser disk, have again "pioneered" these media and drives.

"Data Integration: Integrated Appraisal of Environmental and Cost Performance—Dr Don McLean, Integrated Environmental Solutions [8]
The audience were invited to play a simple interactive game. Pilot McLean of the inaugural flight of McLean Airlines, addressing the passengers (audience) asked them to indicate as soon as they felt uncomfortable, as he explained that before building this plane, they had taken a look around Birmingham Airport, sketched a few planes, made physical models with a couple of wings, thrown them in the air for testing, backed up with a few hand calculations and were now fairly confident it would get into the air, but if there were any wobbles, they would do last minute bits to it! He explained the building parallel, where the disintegrated members of the design team are without any real understanding of how the building will operate until it is actually built and we ask people to use it. The team tends to concentrate on building **production,** rather than building **performance,** without any real understanding of how the building will **operate** until it is actually built. Clearly this is inefficient and costly. **IES are trying to give the design team the information that allows them to assess how the building will perform prior to being built.**
By comparison he panned through **"the IES <Virtual Environment>** a unique system that extends the concept of Virtual Reality for building designers. Instead of only visualising the 3D space the designer can investigate how the building will perform in terms of daylight and electric light, occupant comfort, low energy design, air quality, sustainability, health and safety, and capital and running costs. To be able to perform these assessments computer software is required that will simulate the building. This is equivalent to building a physical model of the building within the computer and testing how the building will operate. The IES <Virtual Environment> consists of simulation software, which provides invaluable information that enables architects and engineers to have much greater insight into how the building will actually perform after it has been built. Consequently, designers can optimise their designs, thereby improving the quality of the built environment for the benefits of society in terms of better buildings using less of Earth's resources. Many experts recognise that simulation software will have a greater impact on the design process than CAD. Already building simulation technology is being used on an increasing number of projects.
The <Virtual Environment> system has been proven to not only enhance the design process but also result in significant capital and running cost savings.

[8] Dr Don MacLean, Integrated Environmental Solutions Ltd,Glasgow drdon@globalnet.co.uk,drdon@ies4d.co.uk http://www.mies4d.com

However, in the longer term, the use of simulation technology will result in a shift of emphasis in the design process. The design process will be no longer centred on CAD, as more effort will be taken at the early stages of the design process allowing design teams to make more effective design decisions. With the proliferation of simulation technology it is possible to achieve the 30% savings in building costs identified in the Latham and Egan reports. The <Virtual Environment> is available now and is already helping architects and engineers provide us with a better-built environment.

The <Virtual Environment> operates from a base model of the building, called the Integrated Data Model or (IDM), created by the IES ModelBuilder. The ModelBuilder allows users to create models of the building that can be used with and without CAD data allowing the designer control of the design process.

There are **five distinct categories or product ranges**, other than the model building tools, as follows:
The DEFT Product Range. Design feasibility tools built around a Value Engineering tool called IDEAL.
DEFT stands for Design Evaluation and Feasibility Tools. **The Facet M&E Calculation Product Range** is a set of productivity design tools for Mechanical and Electrical design. **The VE-Draft Product Range** is a range of M&E drafting tools for building designers. **The 4D Building Simulation Product Range** is a unique set of design based simulation products. These products are easy to learn for in-house use. **The 4D+ Product Range** are physics based, detailed simulation tools for use by committed organisations.

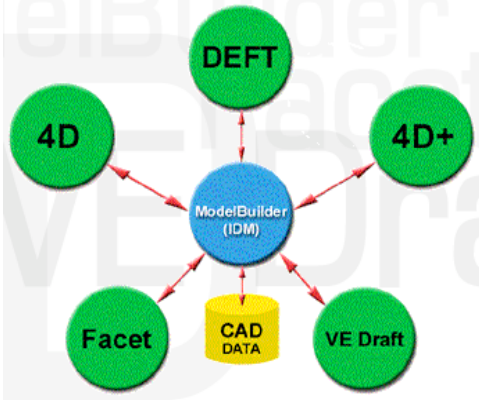


Figure 2: The 5 product ranges. © ies.

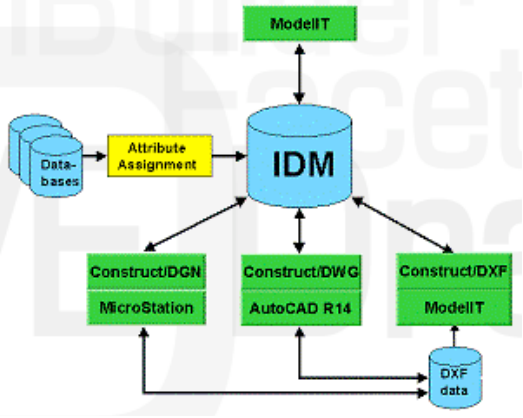


Figure 3: Model Builder. © ies.

ModelBuilder
The major advantage of an **Integrated Data Model (IDM)** is the substantial reduction in time and effort required compared with using the many different products which each require a different data model. ModelBuilder is key to the IDM as the ModelBuilder is a suite of integrated software tools which provide an interface for the creation and subsequent modification of the IDM for the IES <Virtual Environment>.
The starting point for the IDM is a 3D geometry model of the building. This can be created from one or more sources: CAD data available via data converters; or using the IES 3D geometry creation and manipulation software called ModelIT. Attributes are automatically assigned to the 3D geometry of the model to complete the IDM in **ModelIT**. The ModelBuilder is easy to learn and

use, and allows the user to build models rapidly, with good data checking facilities.

1. **The DEFT Product Range** is aimed at providing analyses of the building at the earliest stages of the design process. The tools within DEFT are unique and offer the designer the ability to perform Value Engineering assessments at any stage of the design process. However, this facility has maximum impact at the early stages of design. Organisations can compare building options based upon variables such as capital cost and thermal performance. The basic concept associated with DEFT is that key performance indices are calculated. These indices can be weighted to enable the effects of different building design options to be compared more effectively allowing the people involved in decision making to do so based upon accurate information.

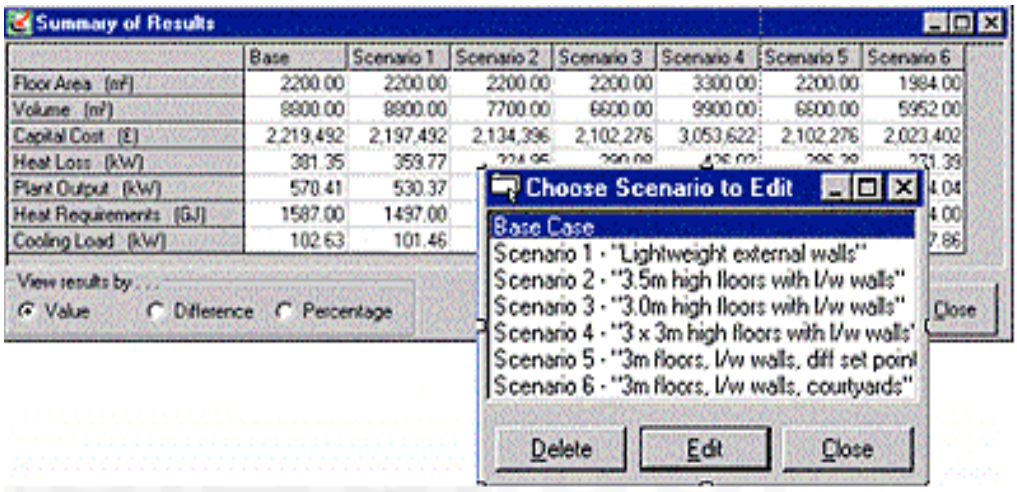


Figure 4:Analysis of any building design option based on weighted performance indicators at earliest stages. © ies.

2. The 4D Building Simulation Product Range consists of building simulation software that can be used to conduct performance assessment analyses to provide an understanding of how a new, or refurbished, building will operate prior to being built in terms of air flow, energy usage, occupant comfort, lighting, and so on. Substantial capital and running cost savings can be achieved with the 4D tools either at the design stage or as part of Energy and Facilities Management. The 4D performance assessment tools operate on the IDM of the building, created by ModelBuilder: thereby maximising the use of the time spent initially creating the model of the building. The 4D range consists of modules that are easy to learn how to run and use. This is an important distinction when compared to the 4D+ products.

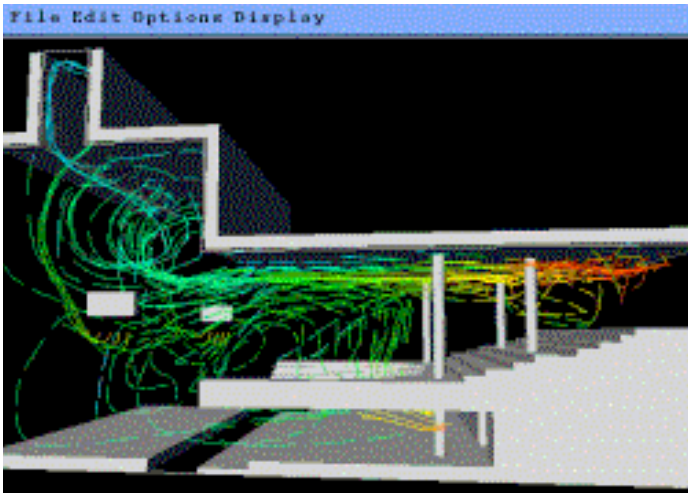


Figure 5: CFD Airflow Simulation. © ies.

3. The 4D+ product range is a complementary suite of building simulation products to the 4D Product Range. The major difference between 4D and 4D+ is that the 4D+ product range is more detailed, only to be used by committed organisations. The 4D+ products tend to require more training and more experience to get the best results.
4. The Facet range of design calculation software is a powerful set of building-services applications for use by Mechanical and Electrical engineers. With Facet software, you will be able to calculate heat losses and heat gains; pipe and duct sizes; lighting requirements and levels; cable sizes; noise levels and more - with accuracy and ease. The Facet products are simple to use, and significantly increase design productivity and efficiency. The Facet design calculation tools, which have been developed by engineers for use by engineers, are widely recognised as the most technically credible products of their type on the market. The technical excellence and benefits of the products are well recognised and appreciated by Facet users.
5. The VE-Draft product range is a powerful set of CAD drafting tools, which help the designer achieve substantial productivity gains when using AutoCAD and MicroStation. Designers working within a CAD system can call upon the **Facet** calculation tools for heat loss and heat gain calculations; pipe, duct and cable sizing; and lighting-design and analysis**"**.

Comment
The world's first "Environmental Reality" system allows building designers, owners and occupiers to simulate the performance of a proposed new or refurbished building. The company is called "*ies4d"* because, for the first time, it adds a new dimension to existing CAD systems by considering *time* as a parameter. <Virtual Environment> can achieve impressive capital and running cost savings. Capital costs of £300,000 were, for example, saved on a recent project. Significant environmental benefits in the form of reduced energy consumption and subsequent reduced greenhouse gas emissions have frequently been achieved using the software which performs thermal simulations of buildings and plant, solar shading analysis, visual impact assessment, airflow and lighting simulations, as well as tariff analyses and selection. In addition, <Virtual Environment> can help solve many of the "Sick

Building" issues such as: minimising the extent of summertime overheating; the use of natural ventilation against air conditioning; the optimisation of occupant comfort; the effect of local air regimes and quality on occupant health and performance.
McLean's presentation of the 'IES Virtual Environment' appeared to resolve so many of the dilemmas of design today, bringing tremendous flexibility, yet potential for accurate targeting and resolution of: the client's needs, economy and the many other criteria to be tested. Examples of projects where the software described above has been successfully applied are myriad and impressive. IES has worked on many high profile projects such as the BlueWater Shopping Mall (the largest in Europe), The Royal Albert Hall and The Millennium Dome, regarding which the construction minister, Nick Raynsford stated (Gardner, 1998): "At the Millenium Dome, the clients, consultants and contractors have been linked together allowing easy exchange of documentation". Whilst not all the software is unique, the interactive total bundle probably is and can be operated in association with known CAD products. This software was developed by Don McLean and the Integrated Environmental Services team over 20 years, initially on Unix predominantly to provide a design consultancy support service, but they are now migrating their software to pc to make it available for sale. One client reported back when their building was completed to say it was "performing exactly the way you said it would"—a small indication of their great success. The software is impressively based in the rationale of each process, thought through relevantly to embrace important criteria, but not wasting time in irrelevance. For instance, only the simple break point of relevance is calculated, to show critical levels, but when testing for evacuation—simulation (e.g. from a football stadium) allocates in detail, behaviour by type of person and how they will move, even twisting into available spaces. High costs in time and possible failure of the design to meet the client's criteria, [whilst being in a rather blinkered state during debate with the design team at the conceptual design stage], can be saved through careful use of this software. IDEAL within DEFT enables Life Cycle Analyses to understand what the client wants and what people in the team are going to do. Important design needs can be fed in at an early stage and tested out. Alternative parameters and criteria can provide a clear technical and marketing differential of what you are doing in different options giving out different performance.

The simulations can be seen to be tremendously useful in facilitating informed, reliable decisions. The technical data are shown as 3D visualisations, making greater sense to all members of the design decision making team from lay client to the most technical and allowing them to "start to mould the clay." McLean made it clear that opportunities for successful realisation of designs, now improve performance at all stages including giving precise parameters for all components in the building process, so avoiding the traditions of oversizing for safety.
Mr Doug Wilkie, of IES has said, "We believe that existing CAD users will prove a receptive market for <Virtual Environment> because it will run on their existing hardware and it will offer them a real competitive edge when dealing with their clients who increasingly seek better solutions and proof of performance."

Data Integration and Reburbishment Design—Richard Thorpe, Crampin Pring McArtney [9]

The Adams Building Nottingham

The presentation concentrated on the use of ArchiCAD on a £16m refurbishment project.

The Adams building is a Grade 2* listed building in the heart of Nottingham. Built around 1855 with gross floor area of 11000m2 approx. It was originally used in lace manufacture. In later years it was in multiple occupancy and was suffering from a lack of maintenance. The refurbishment involved the change of use to Further Education. It was funded from various sources including the Heritage Lottery Fund and Private Finance Initiative.

CAD data for the project came from several sources, e.g. survey, structural engineers, service engineers and several specialist sub contractors. This was from various CAD programs. DXF was used generally for transfer. There were problems with this, the result of which was that a single project model was never assembled. This did lead to some coordination problems on site but none which were insurmountable. The important thing was that the architect's plans were used as the base for all other disciplines. Output from ArchiCAD was used for many varied uses ranging from working drawings to 3D rendered drawings of specific areas and stylised plans for signs. The latter were important in the submissions to English Heritage for LBCs & funding. The ArchiCAD model was also used for quantity takeoffs for floor finishes, etc. and for Further Education Funding Council area use analysis.

Overall the project was completed on time within budget and has started the urban regeneration process in an important part of the city. It would have been very difficult to have completed it on time using traditional drawing methods. Whilst there were some problems with the use of different CAD packages they were overcome relatively easily. ArchiCAD proved itself to be a very flexible progam which easily coped with the demands of the project.

The project is deemed to be a success by the users and as a practice we are delighted to have contributed to it".

Comment

Richard Thorpe illustrated the whole process in great detail in his live presentation, demonstrating how use of 3D CAAD object modelling brought to this Nottingham Lace Market project:

flexibility, team coordination facilities, Client/User's space planning opportunities, greater speed in executing the project, ease of production of outputs for working drawings, quantities takeoffs and promotional information.

The data exchange between CAAD programs was not quite seamless at the time, though doubtless, he would now not have encountered these difficulties through use of DWG with the new version developments.

"Integration Using Component Based Design: Contractors Case Study—David Pyle, Taylor Woodrow and Frank McLeod, HJT Consulting Engineers [10]

[9] Richard Thorpe, Crampin Pring McArtney, nottingham@ cpm-architects.com

[10] David Pyle, Taylor Woodrow Construction Ltd. Europe (Building Division), david.pyle@taywood.co.uk

The context of our presentation on component based design, is to give you an insight into the project, which we are working on with BAA Gatwick. Our purpose is really to try to give you a vision of what we need as end users, or effectively your clients. 'Rethinking Construction: The Report of the Construction Task Force' (Egan, 1998)'s influence on the industry and how we have got to align with his thinking, has really set us as suppliers, five drivers and four processes that we have to try to look at and try to implement *improvement, project implementation, production of components and integrate the process & the team:*

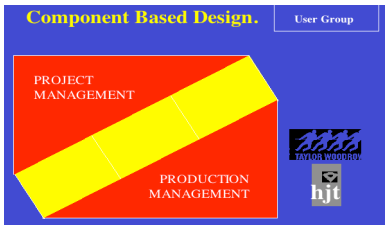
Drivers

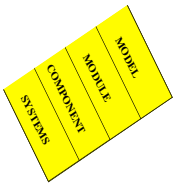
- Committed Leadership
- A focus on the customer
- Integrate the process & the team
- Quality driven agenda
- Commitment to people

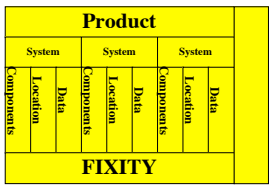
Processes

- Product development
- Project implementation
- Partnering the supply chain

We consider we need a pull not push approach to the construction industry. We have created an environment where we can integrate the team. We had to define the Component Based Design process—"The process of developing a design based upon the maximum usage of standard components, placed in the context of the project so as deliver the greatest benefit. Designing in a modular manner set the scene for modular construction".







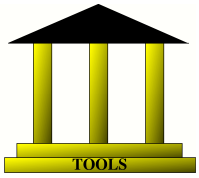
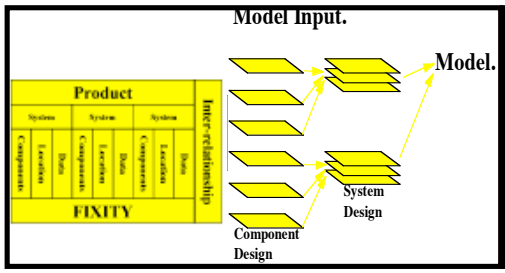
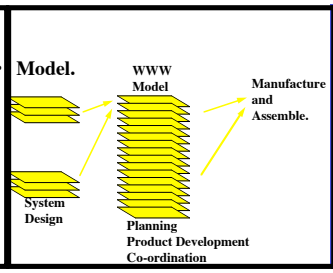


Figure 6: The central D, M & A strip of interest. Figure 7: The breakdown. Figure 8: 'Fixing' the components. Figure 9: We have P,P,P,but no tools.





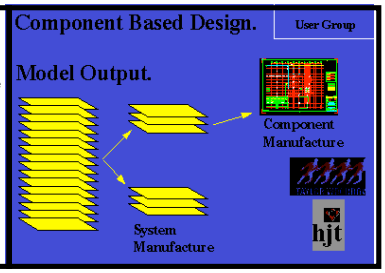


Figure10: Model Input Figure11: Model. Figure12: Model Output of component.

Production of components.

We are taking a first step in production of components. By designing in a modular manner and using available components, we have been able to

achieve significant improvements now, but, more important we will set the scene for the modular designer. That then leads on to prefabrication. The problems you've got on the project are about getting the rigors into it. It's an evolutionary process. It is about us aligning ourselves with Utopia, but getting rigor into every step in the project of component based design. Designers are delivering information to the construction industry. Quantity Surveyors have to become cost stylists as part of the design process. The design starts with understanding the system and components. Define the products at BAA e.g. baggage handling, etc.. Define the system, e.g. Chilling. And we want some data on the components—Time, cost, etc.. What fixes the component? What would allow us to run off these components? Doing that you get the component's Fixity. Last Planner says "You have to make the component" You need those x things before you can make it. Then we look at interrelationships,[Fig.10]. Process maps fill the wall. Design team meetings are about full intellectual understanding of how the building works. We can source the whole project on day 1 *and choose the best experts* to place components in the building. We have the right *PEOPLE, PARTS AND PROCESSES. [See Fig.9]* We will tell the architects "You are not allowed to build unless you fully understand the building." We will whack Egan's 30%. The model is a database—a massive repository of information. A real time coordinator can say 'excuse me you have just clashed with something else". We want small handleable packets of data to work on separately, for easy handling. We want the model coordinated early for components with very simple diagrams as output, e.g. put tab A into slot B.
What are the tools? (Fig. 9) The final thing we need is to facilitate the funds to create the tools. It is not going to stifle design of beautiful buildings. (Figures 6 to 12 © D. Pyle and Frank McLeod).

Comment
This exemplary case study indicates the benefits of understanding the process, breaking the process down into deliverable components to design a system to input and output simply and reliably. Working through the whole process backwards they want the model to come out into component manufacturing.

Sharing of Data for Design and Build Contracts—Philip Palmer HBGConstruction [11]

The HBG Construction and Intranet Drawing Issue System
The HBG Construction Intranet Issue System utilises Internet technology to make CAD drawing data available to members of the design and construction team. The objective of the system was to provide a ëpullí rather than a ëpushí system where drawings are made available in a central location via a Web server.
The system involves various cgi and perl scripts to post forms, etc. to the Intranet server. The Intranet server comprises of a Silicon Graphics Webforce server running from one of our many Sonata CAD workstations. The system firstly **registers drawings** via certain question and answer forms and **is structured to take account of all design discipline drawings** along with

[11] Phil Palmer, CAD Developments Manager, HBG Construction, ppalmer@hbgc.co.uk

any sub-contractor drawings we may have to issue on their behalf. Any user with the necessary permissions can then issue the drawings they require from the register and **also choose who to issue them to** via certain scripted forms. The system will then produce **a static web page of the issue sheet** along with the list of drawings they have issued. Hyperlinks are added to the drawings so that the users can then simply click on the hyperlink which will then **launch a suitable viewer** to view the file on the web server.
Various file options were looked at for publishing to the web and due to the lack of file type exports from Sonata, (our main CAD system), we decided to **publish direct HPGL plot files** which we could also easily obtain from our sub-contractors, etc.. A cheap plot **file viewer** was then installed as an application on the design team's PCs which gave them the ability to **view, print areas to local A3 and A4 printers or plot the entire drawing** to a large format plotter. For site purposes **we provided the site with a suitable plotter**, so they could then plot the drawing out at full size if it was deemed necessary and then any additional prints could be sourced from a local printer close to the site.
The system was successfully used on two main contracts to the value of £80m at Thames Valley Park in Reading for two of our clients Oracle and Argent Development Consortium.

Future improvements, database development and inclusion of client and consultant access
The system was initially tried as a pilot and was very successful in its use and saved much time in providing the design team with instant access to drawings along with a direct link to site rather than waiting for drawings to be posted. The future intention is to make our Intranet area accessible to the client and his consultant team as at present it is an ëin-houseí system. Certain areas are being looked at including network security for dial-up networking, file format for publishing, viewer technologies and current line speeds from remote sites. The future intention is to further develop the system to include a database behind the system to give us more flexibility in what we can achieve and to make the system available to all members of the project and provide a secure Extranet based system".

Comment
Phil Palmer shows here, how HBG Construction's CAD Organisational and Profitability Strategy for data integration within a multi-discipline Design and Build environment has provided data to the project teams on an Intranet Server for distribution. Software and hardware have been designed to introduce□□ □n□e□w□ □t□e□c□h□n□o□l□o□g□y□ □t□o□ □p□e□o□p□l□e'□s□ d□e□s□k□t□o□p□s and on site, (in an excellent Intranet based, ease of use implementation), in order to coordinate and distribute drawings between the design team, subcontractors and the site construction team, so bringing great cost savings. It will be interesting to compare the delivery of their plans to provide access for the client and consultancy team, implemented through an Extranet with the early implementations of client control through CAAD by Sasada, (1994, 1995).

Data Integration and the Building User— Rachel Perrin, Scottish Provident [12]

"Rachel Perrin is a qualified Interior Designer working for Scottish Provident UK. She and her colleague Nadia Zokhrouf from the Space Planning team in the Premises Department are supporting Facilies Management, strategic allocation of space, ascertaining departmental working relationships, procurement of suitable accommodation and liason with architects, consultant engineers and other professionals, whilst responding to constantly changing business requirements.

Their task indicates a need for integration of a variety of data and functions, namely "The integration of the client's requirements with building facilities and services to accommodate staff in efficient groupings and produce the best working environment, while paying due heed to Health and Safety and other legislation. Cost and feasibility are also taken into account."

The Scottish Provident's premises complex in Edinburgh comprises an early 1960's modernist glass and granite, grade "B" building and an admix of Georgian and Victorian facades. A total refurbishment to modern deep plan offices had left only the facades as original".

Rachel Perrin and Nadia Zokhrouf worked closely with the contracted architects on relocation and redesign of a centrally placed staff restaurant and meeting place to be easily accessed from all new areas of the administrative centre. The team promoted Fletchers Joseph Architects' ideas through ArchiCAD visualisations. The team's selection of materials and textures produced an exceptionally accurate indication of how the design would look. Rachel showed a number of paired examples of photorenders with photographs of the materialised scheme, which indicated this. They did also consider that the ArchiCAD facilities for design, space planning, walkthrough and 3D were advantageous "when demonstrating layout concepts to clients uncomfortable with architectural drawings".

Comment

This project demonstrated integration of the processes fully involving the roles of contract architects, interior designers, facilities managers, space planners, engineers, client user and occupant groups.

Model Data Integration in the UK Construction Industry—Dr Robert Amor, BRE/CCIT [13]

"This presentation looked at the grand vision of Integration which is a repository of all project information, lasting the whole life of a building or project, including all relevant views for the different industry groups, available to all in the project, and always consistent and up-to-date. This view is clearly decades from a reality, but many inroads have been made towards achieving this goal. Work on this area over the last two decades has highlighted several lessons, including: the fact that integrated systems have to be tightly linked with all processes in a project; that documentation aspects of a project have to be tightly coupled with the data aspects; that legality aspects need to be considered in the development and use of an integrated system.

[12] Rachel Perrin, Scottish Provident

[13] Dr Robert Amor, Centre for Construction IT, Building Research Establishment, Bucknalls Lane, Garston, Watford WD2 7JR, UK, trebor@bre.co.uk, Phone: +44-1923-664549, FAX: +44-1923-664689, WWW Home Page: http://www.bre.co.uk/ccit/

A survey of the history of integration work shows that many of the concepts pre-date computerisation, including the work (continuing) on classification systems. The 1960's saw the development of simulation tools and even VR prototypes which highlighted the need for integration across these systems. The 1970's saw the development of CAD as the integrator and DXF and IGES definitions which only partially tackle the integration problem. The 1980's saw the development of ISO-STEP models for construction, but with little success. The 1990's saw the industry-led development of IAI-IFCs for standardisation, as an underpinning development towards integration.
A survey of the work being undertaken in the UK shows two distinct camps. In the research and government supported development there have been many prototypes in limited domains and for limited life-cycles. These have tended not to be scaleable to commercial systems. In the commercial world there are no systems for sale, but some in-house development to provide consultancy edge. These systems tend towards project specific, with a small number of tools, bespoke communication regimes, and bespoke data models. Analysing the current situation indicates that in the next few years integrated systems of a limited scope are likely to become more common throughout the industry. However, the ultimate goal is not on the immediate horizon".

Comment
Amor summarises clearly for us how the notion of data transfer and integration predated much of UK CAD developments and has continued into the era of CAAD implementation in the Construction Industry in the UK, but in a very incomplete manner. He considers that, "In the commercial world there are no systems for sale" and that "the ultimate goal is not on the immediate horizon", yet he may have been pleasantly surprised by Don McLean's announcement that Integrated Environmental Systems' suite of software has now moved from their consultancy use, into the marketplace.

"CAD Integration in Scandinavia Compared to the UK—Prof. Rob Howard, Technical University of Denmark [14]
This presentation provided a comparison of progress in Scandinavia compared with the UK and covered background to the survey data and research programmes in Scandinavia, surveys with Sweden and Finland which have major IT development, cooperation with other Scandinavians via Extended Nordic Collaboration, initiative, programmes, integration - an early goal now being realised - benefits expected in Denmark, standards - summary of progress with CAD layers, STEP and IFCs, Scandinavia - levels of CAD use, types of data structures, communications and the future - how integration evolves, changes in construction and when is the pay off. The full presentation can be obtained from the author, however a resume only is provided here.
"The survey of Information Technology use in architects, engineers, contractors, building managers, trades people and material suppliers, was started by the Building Economics Department at KTH as part of the Swedish IT Bygg project. The same questions were asked in Finland as part of their national IT project, TEKES, and its VERA building initiative. In Denmark there is no similar national IT project but, to maintain the idea of an IT Bygg centre and identify how it could promote use of IT, it was felt important to update

[14] Professor Rob Howard, Graphical Communications, Technical University of Denmark, rh@gk.dtu.dk www.ifp.dtu.dk/~it/itprh/html

information last collected by Lars Schiott Sorensen of DTU (Sorenson,1995). Norway was not included, but some comparable data for the UK was supplied by Barbour Index on their users' access to computers and the Internet (Barbour Compendium, 1998). [See Fig. 13]

Integration

The need for integration was identified in the 1970s. The single, common database is difficult to build. It is more successful to link a few applications. Modelling offers objects for integration. Partnering on projects allows data sharing. Research exists on IT in Danish housing consortia. The Nordic IAI is active in the development of IFCs.

INTERNATIONAL COMPARISON OF IT BAROMETER RESULTS

	Denmark	Finland	Sweden	U K
	IT Barometer	Vera	IT Barometer	Barbour Index
	103 firms	38 firms	636 firms	6000 people
	mainly arch, eng,contr,FM	arch, eng FM, B'S	arch,eng,contr surv,FM,crafts	mainly arch surv,eng,contr
Staff use of technology	1998	1997	1998	1998
Have own computer	86%	86%	74%	68%
Company uses CAD	71%	79%	73%	50%
Access to Internet	61%	71%	57%	42%
Use of Email	37%	76%	61%	22%
Use of modem	34%	84%	47%	45%

Figure 13: International Comparisons: Finland has most commitment to IT.

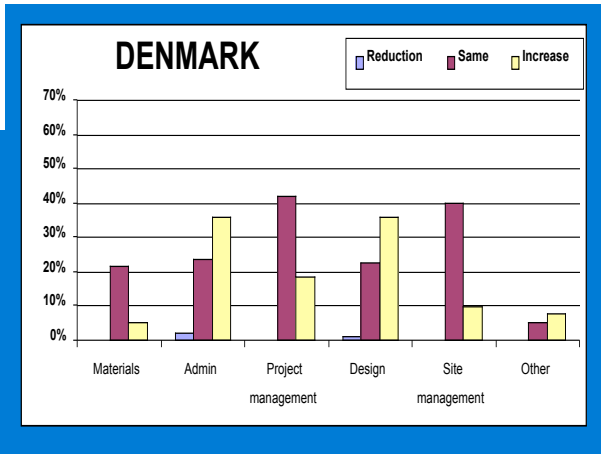


Figure 14: Productivity from IT Admin and design benefit, not management.

Effects of IT on productivity

The message from the Danish survey on the greatest increase in productivity is very clear - administration and design are the two tasks on which the greatest number of firms were enhancing their performance, and this is reflected in Sweden only with even more firms claiming greater productivity. Management fields, such as project management and, particularly, site management, showed little change in most firms. This may be because management applications require greater change in peoples' attitudes and methods of working and do not just involve automating the production of similar documents to the ones produced previously.

Indications of growth in Object oriented models is apparent in Fig.15. In Denmark, strangely only 4% declare use of Object oriented models, yet 8% say they use 2-3D Objects and 265 reference files and databases. Similarly, in Sweden, 11% say they use Object oriented models, yet 24% -2-3D Objects and 22% Reference files and databases. It would seem there may be a misunderstanding of the terminology.

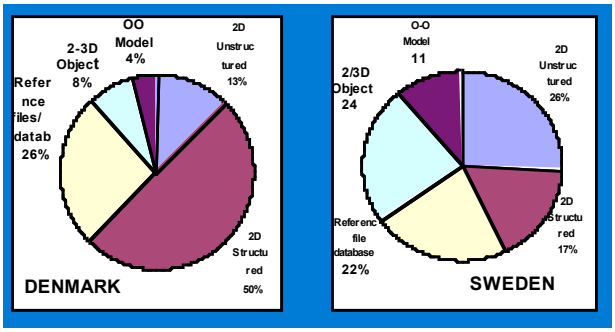


Figure15: CAD Data Structures: Object Oriented. models growing

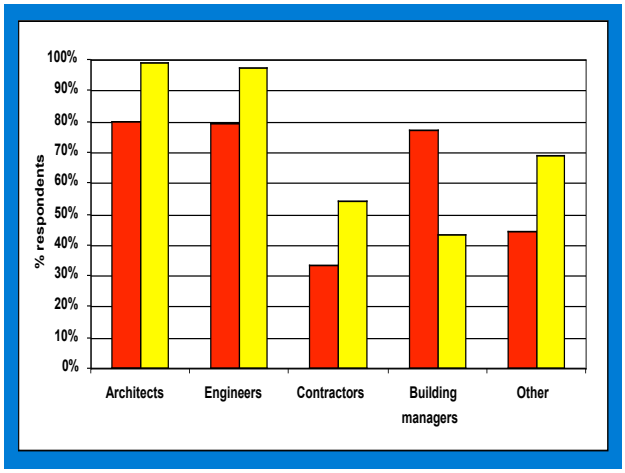


Figure 16: CAD use by type of firm: Some CAD in all Swedish Designers.

Plans for investment in IT in Denmark are also quite clear, although a lower level of investment is expected in the next two years than has been made in the last two. The leading areas in which Danish companies intend to invest, as reported by percentage of respondents, were: CAD (58%), accounting systems (47%) and Internet/Web (46%). Document handling has the highest priority in Sweden (70%), where the CAD market is more saturated, but it is also high in Denmark (37%). Product models, EDI and Virtual Reality have very low priority in both countries, probably because they are new technologies and have yet to show real benefits.

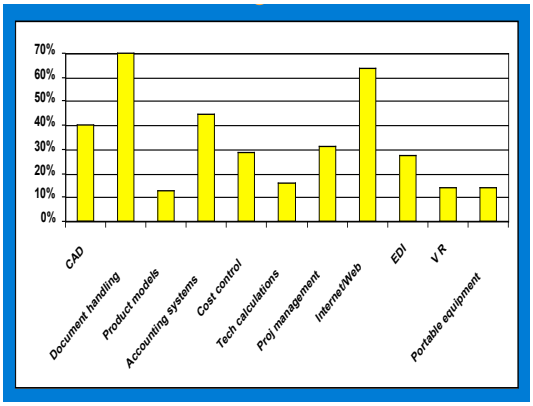


Figure17: Future Investment in IT: document management in Sweden

Figure 18: Summary of Results: Valuable benchmark for future progress

The Future

Products are superseded but integration evolves. Gradual integration of successful applications e.g. NBS, Spec Manager, Annotation Manager, Barbour. Integration needs changes in construction e.g. Partnering, Design & Build, Build Own & Operate. Danish research on Housing Consortia with different levels of IT, measure efficiency of communication. So, when is the payoff? The benefits of IT are improving all the time but fees are lower. IT now taken for granted. 30% savings were nearly reached in recession. If the same team worked on several projects and conformed to relevant standards and there were some useful building objects:

The technology exists now to support real integration, if we can organise ourselves.

Comments
If use of databases and reference files is used as an indicator of data integration processes in Denmark and Sweden then a quarter are active in this way. However a very small % admit to using object oriented models.

Chairman's Summary—Michael Hohmann, LMH Design
The keynote address given by Ray Crotty, MD of C3 Systems Ltd, provided an overview of the construction procurement system as is, and as it should be following the Egan report, which to implement practically, requires the use of virtual building models and the existence of practitioners bridging disciplines, platforms and systems in a forum such as the User Group.
Advanced Visual Technology Ltd, the developers of Sonata, reported the steady interest and investment in installations by major users such as HBG/Kyle Stewart, Alfred McAlpine and Target, the Australian retail group. They also reported on their involvement with several major industry initiatives on Partnering, on industry standard component databases and the IAI. Graphisoft, the developers of ArchiCAD, announced that Version 6 will support IAI IFC 1.5 input/output extensions by mid-1999, a series API associate and easy to use add ons, the new software development kit for use by third-party developers of plug-ins and the debut of "SalesCAD" in Austria for the BauMax-x chain of building materials suppliers.

Conclusions
By the end of the conference the solutions and 'profits' from Data Integration best practice were emerging. Howards' Fig.14 shows exemplary productivity in Denmark. Crotty's diagram gave a clear analysis of the dysfunctional aspects to be researched and resolved. Amor felt we have a long way to go.
A number of the contributors to The User Group conference made common identifications of problems soluble through 3D object orientated building modelling. The first commonly defined problem, focused on the accumulating failures, which escalate, when early conceptual sketch designing does not make key decisions explicit enough to the client, who remains bemused about the architect's dialogue until nearer the realisation of the project, when the designed features become more apparent. Typically at this late stage the client is able to articulate what is required against this more familiar visualised definition. Costly failures are however are incurred at this late stage, in either dissatisfaction, disfunction or uncosted redesign. Fortunately, McLean explained how the 'ies<Virtual Environment>' software addresses these problems, by setting a framework for the professional/client team to clarify important design criteria, which establish objectives with performance indicators, which provide a stark challenge. Some of these processes can be achieved to a limited but useful degree, by a mix of using existing software in a more diagrammatic conceptual manner [block model, analytical approach], together with agreed overt objectives and performance indicators. This occurs early in the process and together with the new electronic sketch designing tools, should bring the designers' conceptualisations into vision for the clients' more informed response, at this early conceptual stage, and clarify and coordinate the whole professional team's thinking, moving towards Crotty's ideal of "What you see is what you get".
A second major and again costly problem is that of the absence of a common language and centre for building dialogue, where all the professionals involved

may relate, test and if necessary modify their input. The present typical mode of working sees abortive, traditional testing, or many separated electronic modelling activities, which are not really collaborative, coordinated, or common and in many ways unnecessarily repetitive, costly and slow to identify features clashing with the design team objectives and professional and industry standards. Again the contributors (and notably McLean) showed that new tools and programs are now available in a coordinated form to ensure related testing/simulations of all the necessary aspects of the building for which each professional is responsible. Nisbet spoke of Sonata's role in "Partnering" and industry standard component databases. Thorpe and Perrin showed how ArchiCAD assisted in data integration processes. Haidekker, Janasa and Hendry showed solutions to this main or second stage problem area and leading into the final working details for the site. Palmer showed some progress with this third problem area and the advantage that will bring to the middle stage design development in turn. Pyle and MacLeod's work on Component Based Design explored Design Manufacturing and Assembly and showed the massive benefits to profitability, working backwards through the process, based on thorough understanding of the building and the components. However they are still waiting for the appropriate tools.

The third recurring problem identified, fell in the later detailing stage of the process. Here inadequate processes for describing and illustrating how the building is to be implemented in practice on the site, sometimes allow designers not to think this important aspect through satisfactorily, leaving much to the imagination of the site team, or necessitating building delays and inactive workers, whilst site meetings and further detailed elaboration are progressed. By associating detailing written descriptions to the components in the detailed 3D electronic building model; there is no ambiguity and such information can be tested out before building on the ground, saving costly long debates on site and even physical disasters, where detailed design problems remain unresolved. One of the contributors was shocked to read of a practice which proudly claimed they only used physical models even for indicating details, despite in his opinion the inability of physical models to define the complexity of today's building technologies. The way forward was illustrated as mentioned in the previous paragraph, by other contributors using component design and scheduling directly off the object based model. Crotty's target required the team to produce output which clearly works on a 'What you see is what you've got to build' principle.

The unique contributions to knowledge reviewed here, actually show interesting drives towards taking greater advantage of computing in the extremely complex process of building design and construction. Results show improved application of software to successfully structure, organise, rationalise, shorten, simplify and improve the quality, performance, delivery and cost of building and ultimately; of user satisfaction.

We begin to see the dawn of a brighter future for better quality and functionality of buildings for the clients and users and a greater ease in successful, more cost effective working processes for the building design and production team.

Those professionals who are migrating into these new ways of working, through electronic virtual modelling of the necessary processes; should also realise their actual fruits in more certain and reasonable costing, improve their reputation competitiveness and hence attract a greater market share of available work.

References

Banwell, H. (1964) The placing and management of contracts for building and civil engineering work HMSO, London.
Barbour Index (1998) Barbour Compendium 1998. Analysis of User Questionnaire
Bennett, J. (1995)Trusting the team the best practice guide to partnering in construction Centre for strategic studies in construction.
Economic Development Committee for Building (Chair Potts, P.G.) NEDO, (1967) Action on Banwell HMSO, London.
detr http://www.detr.gov.com Best Practice Programme.
Doyle, N. (1999) A Setup with more grunt, Building Design, Miller Freeman UK Ltd., Sidcup. March, Issue 1385, pp 23
EDCB (1967) Action on the Banwell Report HMSO, London.
Egan, J. (1999) Rethinking Construction: the report of the construction task force to the Deputy Prime Minster John Prescott: EGAN REPORT, DETR/Stationary Office, London.
Emmerson, H. (1962) Survey of Problems before the Construction Industry a Report prepared for the Minister of Works, HMSO, London.
Fairs, M. (1999) RIBA asks: How much is a good design worth? Building Design, Miller Freeman UK Ltd., Sidcup. March, Issue 1385,p3.
Gardner. G. (1998) Under one roof Building Design Miller Freeman UK Ltd., Sidcup October 2, pp 20/21.
Howard, R. (1998) IT-Barometer survey, Denmark - the use of information technology in building. DTU Rapport 5.
Latham, M. (1994) Constructing the team,: final report of the government/industry review of procurement and contractual arrangements in the UK construction industry HMSO, London.
Ministry of Research. (1994) Info-Society 2000. www.sdn.dk:/pub/info2000
NEDO (1990)Gateway to Europe a manual for the Construction Industry, Stationary Office, London.
Nicholson, R. (1998) Constructing change the architects' journal 25 November, pp62.
The User Group, (1998) Profitting from data integration: an industry update - unpublshed, but reported in this paper, NEC, Birmingham.
Sasada, T. (1994) Open Design Environment and Collaborative Design in Maver T.W. & Petrovic, J. (ed.) The Virtual Studio eCAADe 1994, University of StrathClyde, Glasgow.
Sasada, T. (1995) Computer Graphics as a Communication Medium in the Design Process in Tan, M. (ed.) ICAAD Futures Vol.1 National University of Singapore, Shool of Architectrure.
Sorensen, L.S. (1995). IT-undersogelse '95. DTU Institute for Building & Energy
Samuelson, O. (1998) IT-Barometer Design of a Survey on the use of IT in Construction. MSC Thesis KTH, Stockholm.