

IT DIRECTIONS – 20 YEARS' EXPERIENCE AND FUTURE ACTIVITIES FOR CIB W78

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SUMMARY

This paper looks back 20 years to the first CIB W78 conference that was organised by the author. It builds upon the analysis of themes by Amor & Betts reported at the 2002 conference and includes some analysis of the papers published in the journals *Automation in Construction* and *ITcon*. Trends in topics presented at annual CIB W78 events are analysed and suggestions made for future conference themes and links with other Working Commissions and the needs of developing countries. The role suggested for this successful group is that it continues to help exchange of international experience and encourage collaboration between research and industry and with other groups in CIB.

INTRODUCTION

The first conference of the CIB W78 group, then called Integrated Computer Aided Design, was held at the Building Research Establishment, near London [Howard 1984]. This was an exciting time for developments in IT, with the IBM PC recently launched and the first, primitive version of AutoCAD running on it. The Japanese 5th generation project was frightening the rest of the world with talk of massive processing power, total intercommunication and machine intelligence.

The conference was attended by an impressive audience of invited speakers from around the world including: Tatsuo Terai who said that the Japanese industry ministry, MITI, was getting all the 5th generation funds rather than construction, Paul Richens, then of Applied Research, who speculated on the shape of future CAD systems, and Janet Spoonamore of US Army Construction Engineering Research Laboratory who identified four software needs: databases of technical information, design modelling, expert systems and data exchange.

An analysis of the topics presented at the annual CIB W78 meetings from 1984 – 1991 adds to that from 1992 – 2002 presented by Amor and Betts in Denmark in 2002. Further analysis looks at papers published in two related journals, *Automation in Construction* and *ITcon*, in the last 3 – 5 years. This analysis shows the peaking of various themes as they became timely or fashionable research topics, and the continuing relevance of the needs identified by Janet Spoonamore twenty years ago.

Patterns can be identified, in the evolution over 20 years, of hardware, software, communications, data, and process and human change. Expectations for the first three of these have been realised beyond our imagination, but there is slow progress in some of the remaining areas – the lack of well organised, high quality building data and our inability to change processes or peoples' attitudes.

Of the original objectives from 1984, a few can be said to have been satisfied, others could be with us for all time, and the focus now is on sharing experience and developing the next key stages in a long process. These will be the themes of future CIB W78 meetings, as well as topics that we cannot yet imagine, as the group moves through the next 20 years and involves more contributions from newly industrialised regions such as Eastern Europe, India and China.

20 YEAR ANALYSIS OF PAPERS

Based on the analysis of the period 1992 – 2002 presented by Amor, Betts et al at CIB W78 in Denmark [Amor 2002], and developed in a paper for *ITcon* 'Information technology for construction: recent work and future directions' [Amor 2003], the period has been extended back to the first 1984 CIB W78 conference. Information has been taken from the CIB W78 website [CIB W78], but it does

not list all papers. Some of the events, particularly the 1986 and 1989 meetings in Washington and Barcelona, consisted of a few workshops or keynote speeches. The purpose of this analysis is to show the progress made by the group and to see which research themes have persisted and which have gone away or been taken up by industry. This will allow further comment on the current and future themes discussed in last year's paper. The general trend has been for the number of papers presented to rise steadily over the 19 events held. The first ones involved invited speakers and were quite informal with no paper reviews and only brief summaries published by CIB. They have now grown into academic conferences with full reviews and weighty publications.

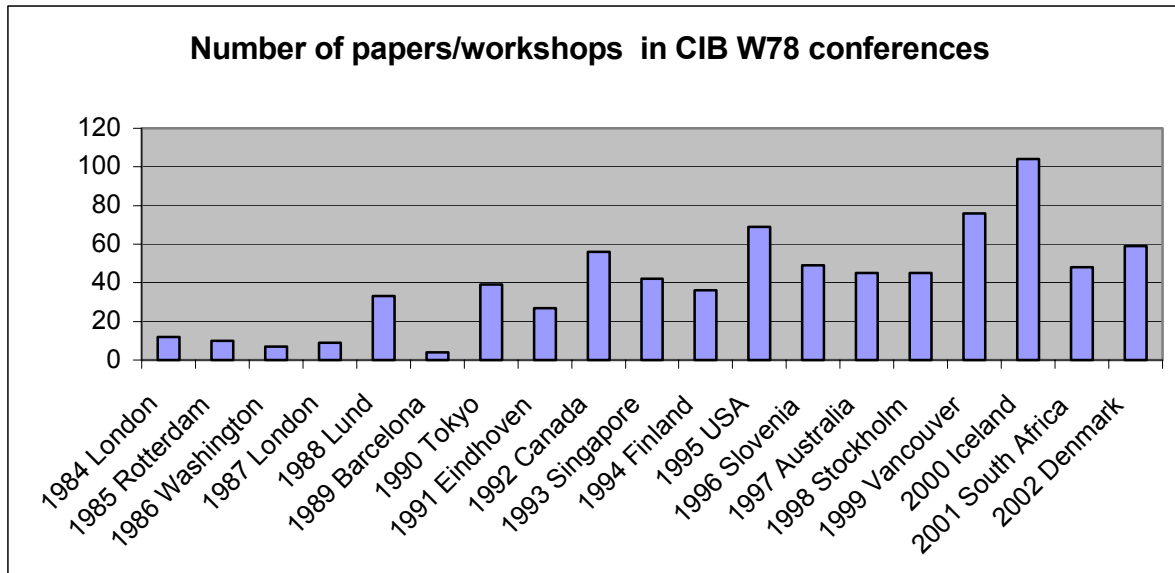


Figure 1 Number of papers and workshops presented at CIB W78 events 1984 – 2002

From the first event, the international nature of the CIB group was apparent with 51 people attending from 13 countries. The analysis of the countries from which papers have come shows an international contribution with North America being slightly higher than any of the three European groups.

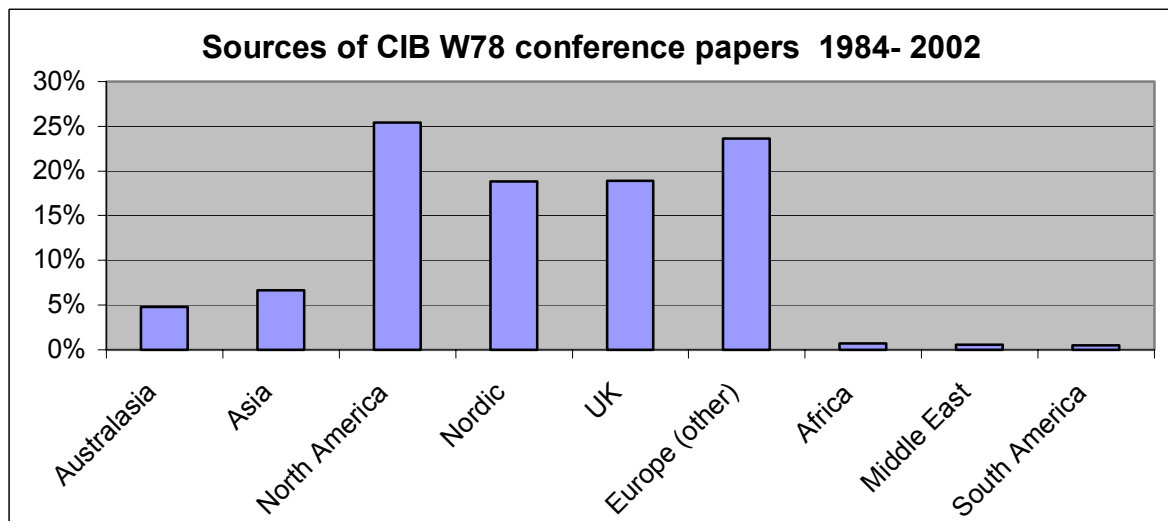


Figure 2 Areas of the world from which W78 papers and workshops have been submitted or invited

The main themes of the papers, which can only be judged from their titles in the early years, except for those with published proceedings, show patterns of growth and decline over a longer period than last year's paper. Some conferences, particularly those with only a few papers or alongside other CIB groups with special themes, exaggerate the representation of some topics, but general trends can be seen in Figures 3 - 6.

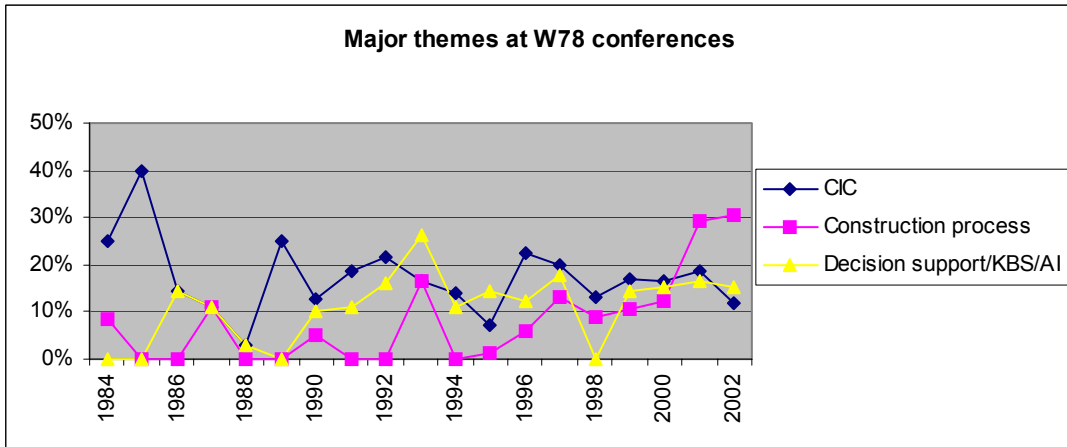


Figure 3 % of papers with main theme on Computer Integrated Construction, Construction process and Decision support, Knowledge Based Systems and Artificial Intelligence

Figure 3 shows a growing concern with the construction process. AI peaked in the early 90s, and integration was always a major concern to a group first called 'Integrated computer aided design'.

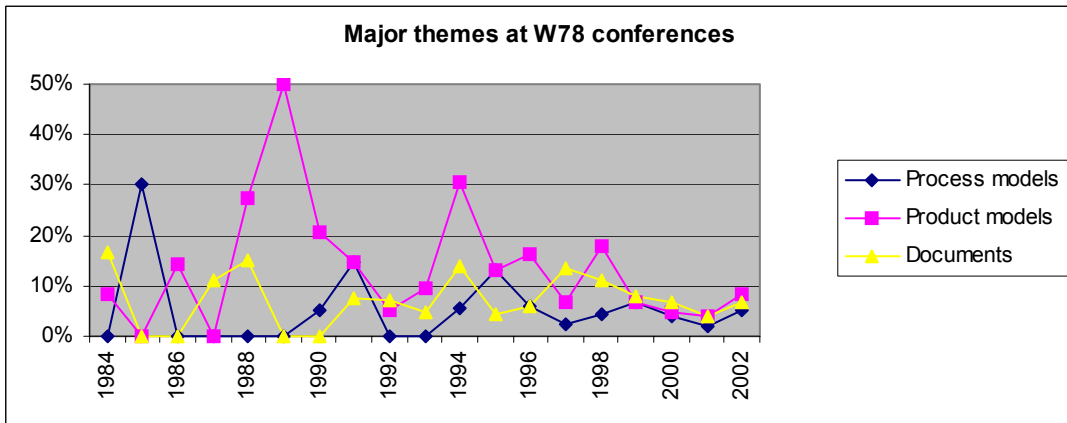


Figure 4 % of papers with main theme on Process or Product models, or Documents

Building modelling has been important to the group, now called 'IT in construction', since the start. Product models have existed since the 1970s, although the peak shown in 1989 was based on just two of four keynote speeches. Process models featured strongly in Holland in 1985 when the work on STEP started at Delft and the conference was organised alongside CAAD futures. Documents are a constant theme but the research has changed from output of electronic documents to management and electronic exchange of such documents. The graphs on STEP and IFCs relate to modeling.

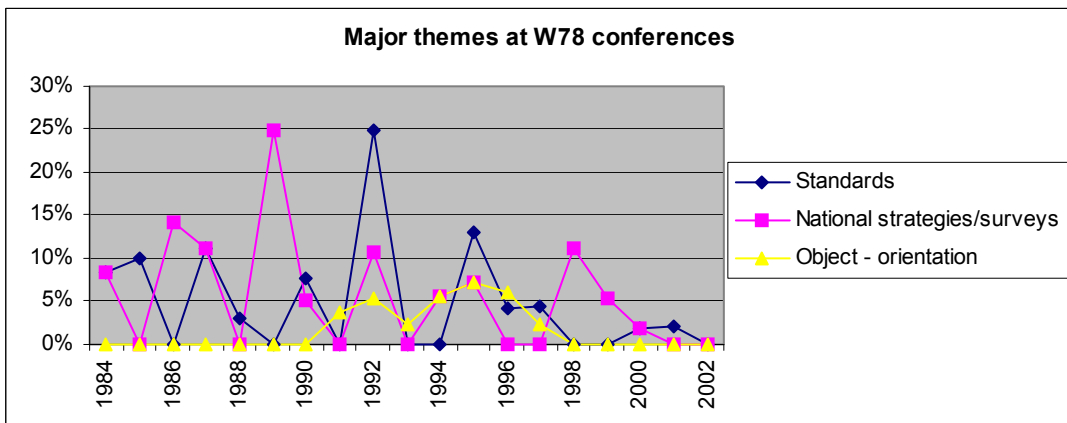


Figure 5 % of papers with main theme on Standards, National strategies/surveys, or O-O software.

Standards were referred to in many papers but their presentation at CIB W78 meetings mostly relates to national or international work such as STEP or CAD layering. National strategies also recur but are not as prominent as the 1989 Barcelona event might suggest. 1998 saw the presentation of the first IT barometer surveys in Scandinavia. Object oriented software was the subject of much research in the 90s but, since then, it has probably been subsumed within other research themes such as IFCs.

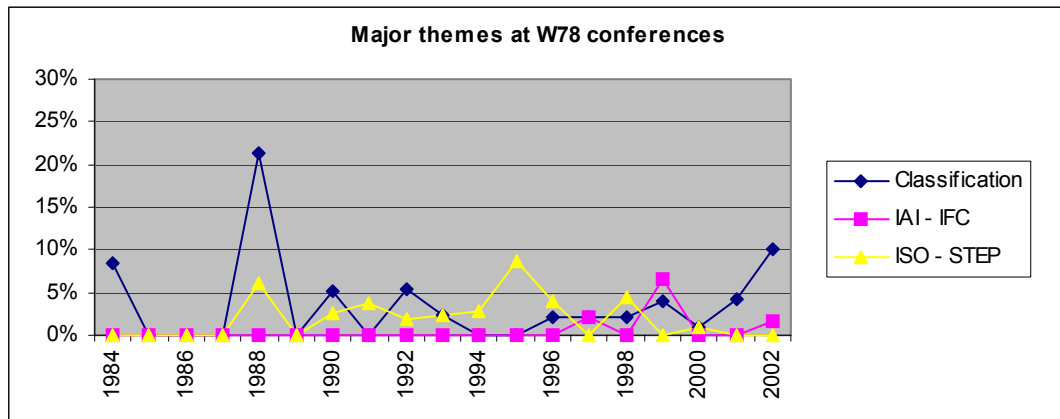


Figure 6 % of papers with main themes on Classification, Industry Foundation Classes and the International Standard for Exchange of Product Models

Classification peaked as a theme in 1988 when the CIB event was held jointly with W74 'Information Coordination in Building' [Christiansson 1988], and has increased again recently. STEP has had its moments as a research theme, particularly in Lund in 1988 and in 1995, but IFCs have only been a primary theme in 1999 since they are mainly a development process driven by industry. They are mentioned frequently in research papers, however.

In this analysis it should not be forgotten that each conference has had a focus and the titles are listed on the CIB W78 website at <http://w78.civil.auc.dk/>

PATTERNS OF DEVELOPMENT OF RESEARCH THEMES

Although representatives from industry have always been encouraged to attend CIB W78 events, since the first years, academic papers have dominated. Topics for research come and go. Some persist throughout the last 20 years and may never have moved into the development phase; others, such as Object Orientation, are in fashion for a time but become subsumed in application areas or general software techniques. We should be aware that, for a theme to disappear may mean that it has been taken over by developers such as software houses, and that the objectives have been achieved, or that the technology was superseded.

Another pattern, over the 40 years in which IT has been used in construction, is that research problems have migrated from hardware in the 1960s, through software, with communications becoming the main agent for change in the 1990s and, as the Internet has provided solutions, the focus has turned to well-organised data, management and change in the construction process. It is difficult to see this pattern from the CIB themes since these are not analysed on such a basis. Any hardware research was largely done in construction before 1984 when the IBM PC started to provide the basis for widely used systems. Software research is represented by object-orientation, product and process models. The Internet was a topic from the start of its use in business in 1995 to the present, and STEP, IFCs and Knowledge based systems represent the recent concern with data.

The topics that Janet Spoonamore identified in 1984 are still current but in rather more mature form:

1. **Databases of technical information** are still incomplete and organised in non-standard ways. The problem is no longer the systems to support them or distribute the data, but who will do the work and enforce the standards necessary for a coordinated and high quality service. E-commerce may eventually solve this problem provided users or suppliers are prepared to pay for a complete service. Databases have not been a major research theme so they need commercial support.

2. **Design modelling** has received more attention than any other theme and yet wide implementation of the product models that exist has been limited to visualisation. Awareness of the advantage of building models has existed since the 1970s, yet they require more radical thinking than has been generally shown. Gradually the hopes for changing from a fragmented 2D world into one that is coordinated and object based are being realised, but most of the industry is happier with documents even if they are now produced and exchanged electronically.
3. **Expert systems** were assigned extraordinary capabilities following the Japanese 5th generation proposals that claimed they would introduce very high levels of machine intelligence. They would encapsulate human knowledge and communicate with us in plain language. Many people were disappointed with the knowledge based systems that did appear, but the idea of handling fuzzy data has re-emerged in knowledge management and decision support.
4. **Data exchange** has also been a continuous theme and solutions of increasing capability have come out of research, but mainly as de facto standards from companies such as Microsoft. In 1984 IGES was being developed as a 2D CAD exchange protocol that never caught on in construction. It was quickly succeeded by STEP and then the IFCs. More pragmatically there were translators between CAD systems, of which AutoCAD's DXF was the most successful. This was enhanced by layering standards and, eventually, object modelling should become the basis for data exchange.

While many new themes have emerged, those identified in 1984 are still current and the emphasis is now on how they fit into the business environment and what changes are needed in processes.

CHANGES IN CONSTRUCTION IN 20 YEARS

The industry, within which most of the CIB contributors operate, has not been static over the period of W78's existence. Many of the research topics have either originated from these changes or have been catalytic in their coming about. The first really productive applications of IT automated parts of a traditional process in which the different members of the building team operated in sequence. This was a survival of the days when representation techniques were fairly static and everyone understood them. In the last 20 years much building design has been seeking novelty of form for its own sake. Some of these forms have only been possible to represent and construct using computer techniques. A good example of this is the sculptural Bilbao Guggenheim museum, designed on a CAD system for modelling aeroplanes with steelwork fabricated from the model. Other examples are tent structures and even buildings with large radius or complex curves, impossible to draw or set out manually.

The biggest change is now felt in the organisation of the process and thinking of a building over its whole lifetime. Improved communications have removed the need for sequential working, and no one member of the team has the right to lead by tradition. The client is becoming more involved since a building is such a large investment, and he can be given not just the geometric data but also that required for lifetime management. The concept of integration around a shared building model means that it has to be owned by the project, effectively the client. IT has made this possible but the question remains, who does most of the work in creating the model and who receives most benefit? This requires partnering since it is difficult to reward team members on the level of their contribution. IT has therefore been the main catalyst in the process changes in building over the last 20 years.

MORE RECENT THEMES FROM JOURNAL PAPERS

When looking at the most recent research themes in construction IT, the two most relevant journals, both supported by CIB, are Automation in Construction and the ITcon on-line journal. The first of these covers various fields not included in CIB W78's agenda, particularly robotics, and has many special themes among its 4-5 times per year issues. ITcon, which is now printed as well as published at <http://itcon.org>, coincides very closely with the CIB W78 area and could be regarded as its journal. A quick review of the titles of the papers from these two, from a recent series of about 30 issues of Automation in Construction and 8 issues of ITcon, gives the following profile using the same themes used to analyse the CIB conferences. Figures 7 & 8.

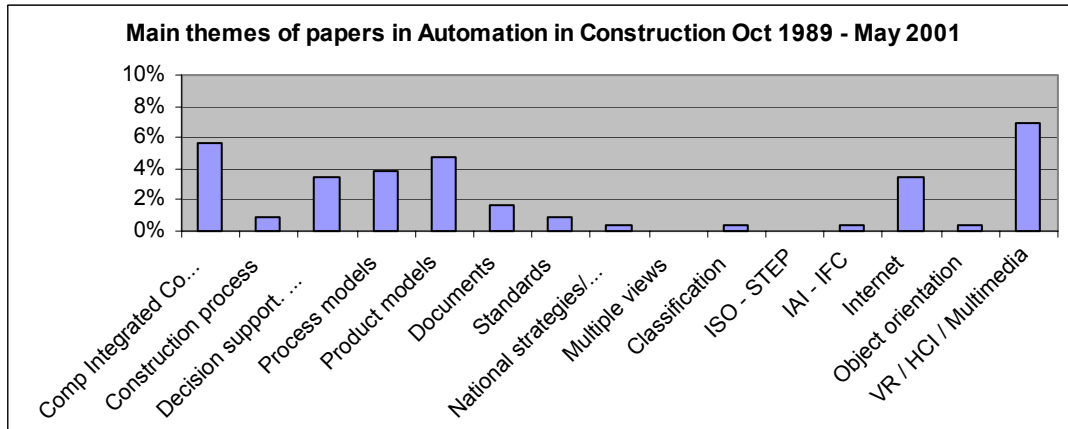


Figure 7 % of IT based themes from papers in Automation in Construction Oct 1989 – May 2001

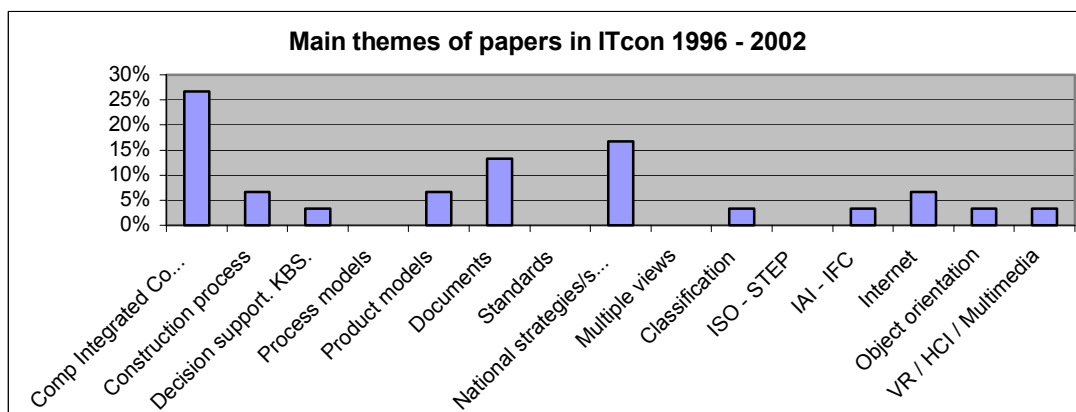


Figure 8 % of themes from ITcon 1996 – 2002 analysed by themes of CIB W78 papers

The first thing to notice is that there is a much lower percentage of IT based papers in [Automation in Construction] and this is because its field includes: architecture and engineering, construction technology, and maintenance and management. However the IT themes are quite prominent with integration, product and process models and Virtual Reality, Human Computer Interface and Multimedia, the most frequent. There have been special issues on modelling and multimedia, and reports from conferences such as eCAADe and ACADIA.

ITcon appears to have a somewhat different focus with integration being the only leading theme in common with the other journal. The other leading topics are documents and national strategies, with process models not featuring as a main theme. However a deeper analysis of each paper would show several of the themes, in addition to the one chosen as the main basis for this analysis.

CURRENT THEMES

The purpose of any retrospective analysis is to point to the future and show, from past experience, how current themes may develop. This analysis was started by Amor and Betts in their paper to CIB W78 Denmark [Amor 2002]. They isolated three broad themes from the current concerns of CIB W78:

- The modelling of processes and products and the integration of this with visualisation and standardisation of information life-cycles
- Issues associated with implementation, adoption and behaviour and the management of technology
- Reengineering of processes and the search for integrated supply chains.

Modelling of processes and products will, it seems, always be with us. It is possible to model in an ever more detailed way until we are simulating all parts of the building, their performance and the process of erecting and managing it, building a virtual building before work starts on site. What is needed is more feedback from usage of all the research that has gone into defining models. Industry has not carried out enough implementation yet to let researchers know whether they are on the right track or not. CIB fulfils a useful role in spreading the experience that does exist. Trends shown by the conference analyses are that the focus has moved from product to process since there is now more change in construction in this area. There is an argument for testing models only on routine buildings.

The more innovative buildings still present challenges for the product models that exist. At the same time that IT has made them possible, new designs will always test the technology's ability to handle them. What can usually be done is to visualise them in ways, such as VR, which make them more real to users and other lay people. Standards are more difficult to apply to unconventional buildings, hence the need to test routine models on more conventional examples. However any good standard should be open ended and allow solutions, even those not yet conceived, to be handled.

Implementation and management of technology was the second area of current themes. It has not been reflected in the analysis of papers, but is of growing importance. IT researchers and developers seem to imagine that any new tool designed to benefit construction will be taken up and will fit into existing management structures. This attitude is starting to change. There are many great IT solutions which have never been taken up; the VR head set is not seen outside research labs in spite of first being demonstrated in 1968. Having disseminated most of the obvious IT solutions across whole companies, attention has now turned to the design and construction process to see how this should respond to other possibilities of IT. In the UK the Egan initiative has been followed up by some leading clients introducing wholesale process change, and private finance for building and operating public facilities has made contractors, in particular, think long-term about life-cycle sustainability.

Human factors become more important when all staff have to use new technology. Early days of IT were dominated by enthusiasts who would suffer poor user interfaces and badly designed software. This has had to change and there are now much more friendly systems available. The more difficult concepts, such as product modelling, could be delivered within widely accepted suites of software or through communication tools such as project extranets. The significance of Microsoft having its own project management software, and buying the Visio drawing tool and Navision enterprise resource planning, is that these could be bundled with existing office tools and become familiar to many.

Reengineering of processes and integrating supply chains, was the third current theme, and is closely coupled with management. The data exchange theme, that has been strong throughout the existence of CIB W78, is about passing data between all those involved in creating and managing buildings and, if possible, retaining it over the lifetime of a building. The original diversity of hardware and software products meant that, before 1984, much of the data exchange effort was on integrating between different IT suppliers. Now there are leading products that set de facto standards, and the Internet as a universal means of communication. This means that research and development can concentrate on filling gaps between design and construction and between supply and management.

The construction process has not appeared as a strong theme in CIB events until recently. However all IT research has implications for the process. What have been needed are some overall goals for these changes to achieve. Other more advanced industries, such as automotive or aerospace, have shown construction what is possible in a more continuous and repetitive process, and construction is starting to follow their example. There is a limit to the level of mass production and evolutionary development that applies in construction, but appointing lead contractors and consultants, and the greater involvement of clients can help to unify a diverse industry.

FUTURE COLLABORATION AND THE ROLE OF IT

Looking at how these themes have developed, in CIB conferences and industry journals, can help us to see where they might be leading and what focus the CIB W78 group should have in the next 20 years. Its relationship with other CIB working commissions should not be forgotten, since there is much overlap. Future conferences could usefully link with some of the most closely related working commissions. The diagram of working commissions is available on the CIB website www.cibworld.nl

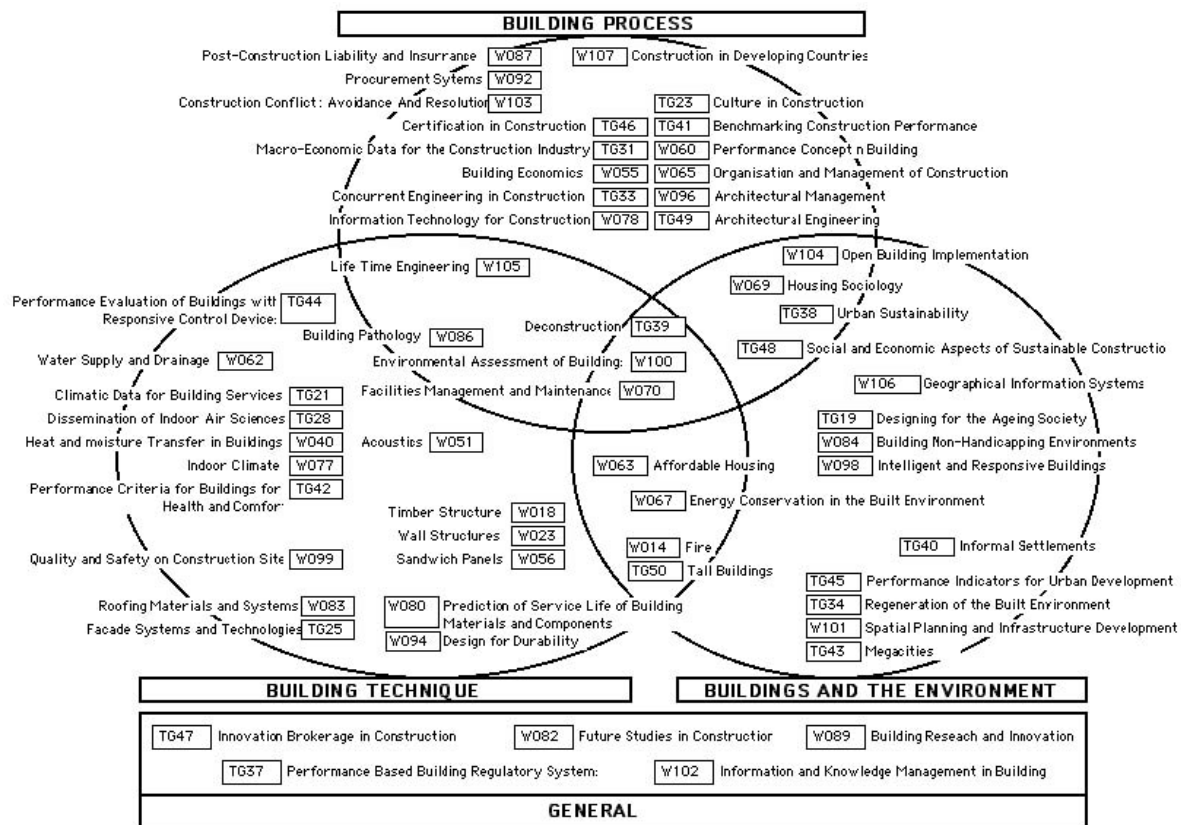


Figure 9 Diagram showing relationships between the currently active CIB working commissions. CIB

From the titles of all the working groups in CIB there would appear to be potential collaboration with many, but the following seem relevant: TG33 Concurrent engineering, TG41 Benchmarking, TG44 Performance evaluation, W100 Environmental assessment, W106 GIS, W098 Intelligent and responsive buildings, and particularly: W082 Future studies, W089 Research and innovation, and W102 Information and knowledge management. Joint events between these groups and CIB W78 could explore the catalytic effect of IT in enabling process change to happen in other areas.

Information technology is so much a part of all research, development and practice that it seems to have outlived its day as a separate discipline. All researchers are familiar with the general capabilities of IT and many of these facilities are on the desks of practitioners and will soon be accessible from mobile devices used by all employed in construction. There is a trend in universities and some governments to talk about innovation rather than the technology. It has been realised that, apart from the basic IT facilities, the information society will not come about without coupling IT with process change. This process change is starting to happen in construction in many developed countries. The Rethinking Construction initiative in the UK is stimulating change, and the development programmes in Sweden and Finland have involved industry in creating and demonstrating advanced systems. The many EU research programmes have brought European researchers closer together, and CIB adds a world dimension to exchange of experience. IT, in its narrow sense, should expect to have a lower profile outside computer science departments in universities. It is the strategic effects of IT on business processes that have become the focus for the next wave of productivity benefits.

FUTURE DIRECTIONS

Returning to the trends identified in the analysis of conference and journal papers, the themes that appear to be growing are the construction process and classification, with product and process models and integration ever present. The themes for the 2003 conference reflect these and introduce some new areas of focus: collaborative working and agent-based project environments. Each successive event needs to encourage papers in new areas while reporting on progress in established ones. Predicting the next direction in which research will go more than a few years ahead is difficult, but all researchers would like to know this. For anyone to embark on a 3 year PhD in IT risks being

overtaken by events. The topic chosen may have progressed from frontline research to implementation in that period. However there are lasting topics, such as those that have recurred in CIB W78 events, in which there is much research still needed. The trend towards focussing on processes and improving organisation of building data depends upon some rather dull, but worthy, research being done. Process change needs to be monitored and the productivity gains from IT systems need to be measured. Industry initiatives, such as Rethinking construction in the UK, may do this in rather superficial ways to promote process change, but it needs longer-term research to provide hard data and ensure that the most fruitful directions are being followed by industry.

CIB W78 conferences help researchers to follow up research and provide a pointer to the future. The analysis from the Construct IT vision in [Amor 2002] points to seven key themes for future change:

- Product and process model driven, rather than document driven, information management
- Life-cycle thinking and seamless transition of information and processes between all phases
- Use of past knowledge in new developments
- Dramatic changes in procurement policies as a result of the Internet
- Improved communications in all life-cycle phases through visualisation
- Increased opportunities for simulation and what-if analysis
- Increased capabilities for change management and process improvement

These certainly reflect the direction of IT research in construction in the most developed countries. The IT products that result are available worldwide, but may not fit into industries that are organised in a more traditional way and do not have the same drive towards process improvement yet. CIB W78 needs to involve more people from developing countries. For example it could hold a joint event with CIB W107 'Construction in developing countries', and find out how the tools from IT research fit into the expectations of the rest of the world. There is evidence that more information-based services are being subcontracted to countries with lower wage rates. There is a limit to which construction services can be transferred across the world, but there is also the consideration that more construction will take place in less developed countries and there is likely to be more international collaboration. CIB W78 can be an important agency, not only in reporting current and future directions for research, but also its application to construction processes in any part of the world and in international cooperation.

The objectives of CIB W78 should continue to be those of encouraging international collaboration. There are few groups in Construction IT that have been as successful in maintaining representation from so many countries. A core of people, from which Martin Betts, Per Christiansson and Bo-Christer Bjork, could be singled out, has provided the continuity, but new people from different countries are adding their ideas to maintain relevance in a fast-changing technological field. There is a limit to what can be expected from busy researchers between the annual conferences, but collaboration continues in the form of shared research involving many members of CIB W78. This ongoing collaboration could now extend to other CIB Working Commissions and, particularly to new parts of the world where the application of information technology in construction may have different priorities.

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