

NATIONAL COLLABORATION FOR INTEGRATED CONSTRUCTION IT

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Abstract

The achievement of computer integrated construction has technical and organisational prerequisites. These may be best met through collaborative efforts between a combination of organisations concerned with research, development and technology transfer. This model for innovation is finding increasing support amongst groups that have a need for research such as government bodies and industry associations. It is also a model that has benefits and an increasing appeal to research providers.

This paper describes how this form of innovation has been adopted in an initiative at the University of Salford in the UK. The model is being used as a basis for collaboration between government, professional institutions and trade associations, contractors, technology transfer groups and researchers.

In particular, the paper focuses on the work and activities that can be undertaken by such a collaborative group and the benefits that this can bring to different parties. The paper concludes by speculating on the need for some similar forms of collaborative ventures on an international basis.

1 INTRODUCTION

In the current climate of technical and industrial innovation it is common to see leading members of different interest groups in an industry, come together. The term centre of excellence has been coined to signify a group of interested parties, each of which is a leader in their field of activity, combining to undertake joint work in the area of innovation. Innovation embraces three related processes of research, development and technology transfer and many of the centres that are emerging are addressing all three.

Such centres of excellence are common in many parts of the world and examples can be found from a number of areas including advanced robotics, management training and information systems in the UK. The concept has been widely followed in many parts of the world. In construction, where our total research efforts are relatively small and where there is such a large range of different types of industry participants, the need for such a form of collaboration is particularly pronounced.



2 PRODUCTIVITY AND QUALITY

Productivity and quality are commonly identified as key challenges facing construction world-wide as we approach the next millennium.

" Dramatic improvements in productivity and quality, coupled with improved management of an integrated design and construction process, are needed to bring UK construction practices up to the level of the best in the world." (NCG, 1988)

The current low levels of productivity in comparison to other industries and our apparent inability to make significant improvement is one reason for this concern as is the continuing inhibiting factor of the high level of industry fragmentation. Quality has emerged as a key issue and takes a greater significance given the poor image our industry has in the context of increasingly sophisticated client demands.

Productivity and quality are key construction priorities to which several types of innovation may potentially bring improvements. IT has a central role to play addressing them both and an initiative based on IT is one of a number of actions that UK construction is taking.

The link between IT and productivity and quality is widely based. Quality has many dimensions to its measurement and achievement. Given a broad view of the property and construction sectors' activities the *quality of information* is a primary influence. High quality information is of great consequence to issues of reliability, reduction of risk and ultimately to all aspects of Total Quality Management. Productivity is also intrinsically linked to information and thus IT. Many of the emerging concepts of lean production (Koskela, 1993) and simultaneous or concurrent engineering have major roles for IT within their realisation.

The two issues of productivity and quality are also bound up in the performance of people. The high quality of the training of construction professionals and the depth and breadth of their experience are key national assets of property and construction sectors. A key requirement for innovation is the development of advanced Information Technologies that are practical, relevant and in tune with the needs and abilities of property and construction people.

3 THE CONSTRUCTION IT OPPORTUNITY

Given the arguments about productivity and quality made above, there is a case to be made for IT to be used as one of a number of means by which both can be improved. However, the need for improvement and innovation in IT in property and construction is more broadly based. The property and construction sector stands on the threshold of an unprecedented IT opportunity. We can illustrate this opportunity in the following ways:

Recent management research (Benjamin and Blunt, 1992) has speculated that the remainder of the 1990's will see dramatic technological advance in IT with cost

performance improvements of two orders of magnitude, inter-connection of computers through very high bandwidth networks and client-servers as the standard computer architecture. *"Many systems developed in the next ten years will be organisational time bombs"*. In construction the explosions will be felt within companies and professions and the relationships between all within the industry. Work by Brochner (1991) and Betts et al (1991) has speculated on these likely industry changes.

The UK Engineering and Physical Sciences Research Council recently announced it's Innovative Manufacturing Initiative and within that cited Construction as a Manufacturing Process as a key research thrust. It painted a scenario for the industry's future:

" the grand design could be a series of expert systems fully integrated into a prestigious 'client-friendly' advanced construction design centre which would exploit virtual reality. It would include an intelligent computer-aided design system and would ultimately contain a wide range of software tools associated with every aspect of construction" (EPSRC, 1994)

This sort of vision clearly shows the exciting possibilities that IT holds for construction. The key to that vision is the intelligent integration of information among the different construction industry participants. The EU Fourth Framework research proposals are for more than 13 billion ECU of research funding over four years with almost 40% being for IT-related research (EU, 1993). In addition a number of other influential UK reports have identified IT as a significant opportunity as the following quotations indicate:

" Integration is the opportunity of the 90s. Those who grasp it will benefit since stand-alone programs are now fully developed." (Building Centre Trust, 1991)

" The RICS will proactively seek to initiate and support research in areas typified by major structural changes. In the medium term the three following areas have been identified: the impact of information technology, the management of increasingly systemic client relations, and the implications of changes in market structures and processes." (RICS, 1992)

" the last three years have been a period of consolidation and widening usage of information technology across the industry. IT budgets have been under severe pressure as a result of the recession but, with signs of recovery... this trend will be quickly reversed - a sign of confidence in IT as a fundamental requirement for an efficient and 'quality' construction process" (CICA, 1993)

Despite the optimism expressed in these quotations, many of construction's early experiences with IT were, at best, frustrating and at worst disastrous. Since then there has been a period of greater understanding and confidence and we now stand on the threshold of a period of great opportunity. IT has come of age and the next ten years will be critical. At the same time current circumstances are such that the bottom line impact of IT and a concern with its short-term effects have given a keen and testing environment in which technological innovation is being assessed.

A major pre-requisite to a breakthrough is the greater realisation of, sympathy to and ability to cope with the variety of people in property and construction. The varied national and professional languages, cultures and perspectives of the great diversity of types of people to be found in our globalising, multi-professional and organisationally fragmented sector are now finding a much closer match up with the broad range of visualisation, multi-media, knowledge-based and decision support technologies (Powell, 1994). The major need is now to bring these together.

Collaborative work in the area is already underway through specific development initiatives such as STEP and EDICON and with particular research projects such as ICON. EDICON is a UK collaborative industry venture to develop and apply Electronic Data Interchange technology in construction.

" CAD Data Exchange, EDI and telecommunications are set to change technical and commercial trading practices radically. Distance between offices will cease to be an issue and all your partners will be as close as the department next door!" (EDICON, 1992)

ICON is a collaborative research project involving three UK professional institutions, representing architects, surveyors and builders, which is developing integrated information models for the construction industry (Aouad *et al*, 1993). Similar collaborative developments such as these have occurred in other countries with national developments in Australia, Canada and Finland particularly noteworthy (Bjork, 1993; Leslie and McKay, 1993; and Vanier *et al*, 1993). Many countries are now recognising the strategic significance of IT to their national property and construction sectors and have begun co-ordinated efforts to respond to and take advantage of these. The following quotations illustrate the nature of some of these developments:

" .. the Australian construction industry .. while information intensive, uses its information in a fragmented way leading to inefficiencies in decision-making, adoption of inappropriate processes and the stifling of innovation. The need for a strategy to address how the industry uses and manages its information has been apparent for some time." (DITRD, 1993)

" The objective of the study is to arrive at specific initiatives to implement strategic IT applications in support of visions for the sector that include being able to compete internationally." (NCB, 1991)

However, in most countries there is no overall framework to monitor the place individual initiatives have in a coherent national research, development and technology transfer strategy. There is a lack of continuity and strategic overview of the full range of information technologies. We are living in a time of significant technological advancements with broad band communications, multi-media information systems, knowledge-based systems, advanced computer visualisation and integrated database technology presenting unique technological opportunities. At the same time, construction is undergoing substantial changes caused by increasingly discerning and demanding clients, gradual professional deregulation, industry restructuring and changing industry business processes.

There is a timely combination of technology-push and strategy-pull forces at play that make IT an urgent priority for property and construction.

4 THE CASE FOR NATIONAL COLLABORATION

Basic and applied research, product development and technology transfer in property and construction have until now been isolated activities. The time is right for the leading players, that emerged during this period of individual working, to come together. Collaboration would promote short and medium term technical exploitation and long-term innovation to the advantage of industry. The rationale for this is the need for joint ventures. The best developments in new fields are more likely to emerge from the combined efforts of organisations that have different interests and motivations and different roles and responsibilities in bringing solutions to fruition. Again some quotations from the UK illustrate some of these arguments:

"..collaborative programmes can help off-set the costs of development work and enable a project to include a longer-term dimension than could be justified using short-term return on investment criteria, or it can enable companies to work with partners normally inaccessible to the firm." (CIC, 1993)

" A building IT forum, based on existing organisations, could promote awareness and provide a focus for integration and standards." (Building Centre Trust, 1991)

Within construction innovation we also can see a need to pool expertise. Because useful experience in this field is so scattered, the real knowledge of the overall situation will only be available through a sharing of expertise. Together this is a powerful force for identifying where to go next with IT in property and construction and how to get there.

Our innovation must also recognise that innovation is based on a research-to-implementation continuum. Effective technological innovation is unlikely to be achieved by a research body, a software company, a government department, or an industry player in isolation. Innovation is a continuous process that starts with basic research and then continues through applied research, development, selling, implementation and then works back through evaluation, updating, redevelopment and measuring the benefits. No one group has the interest or the ability to address all aspects of this continuum but groups of collaborators as a whole have this scope. In particular, they have the ability to co-ordinate those activities currently underway.

" Innovation in construction is not a linear process starting with an idea in a laboratory and then developing through prototype stages to a final marketable product. It is a collection of simultaneous and often disconnected activities. These can range from 'blue sky' research where scientific theory is manipulated into the concepts, processes and devices that provide building blocks for future technologies, to more applied experimentation and product testing." (CIC, 1993)

A further argument for collaborative innovation is the need for competitive advantages for groups of construction firms. The use of IT in property and construction has been repeatedly identified as an important means by which

companies will compete with each other in the deregulating, globalising and increasingly competitive environment that construction has become.

A great deal of property and construction IT research is already underway which is being undertaken by individuals in specialist centres. What we have lacked is the ability to co-ordinate this research. Ensuring gaps are plugged and overlaps are avoided is of crucial importance if the most is to be made of our research and effective dissemination and implementation is to be achieved.

5 THE UK RESPONSE TO THIS SITUATION

In the UK, the response to this situation has been to form a national centre of excellence. The centre has a broad representation of members. These are the centre-managing allies promoting the initiative whose motivation is not personal or financial gain but who have a responsibility to encourage and promote industry advancement. Others are corporate participants who have a commercial interest in acquiring and exploiting the results of the centre's efforts. The way that different types of potential allies and others give coverage to the different aspects of innovation is shown in figures 1 and 2. These also indicate how many types of organisations are able to have an involvement and offer advice to different parts of the innovation cycle as it rotates within the framework of the different contributors to a centre of excellence.

The allies within this centre are independent and non-commercial government departments, trade and professional associations and Universities. The allies effectively run the centre giving it status and leadership as well as offering the insight from their current activities and technical expertise. The corporate participants are a group of forward-thinking and influential UK companies wishing to participate in the centre's research activities. The primary need for them doing so is to inform their corporate IT policies in making technological investments and having made them to protect these investments through being continuously well-informed.

6 THE NATURE OF TECHNOLOGICAL INNOVATION

Technological innovation has three distinct phases of research, development and technology transfer. Figure 1 below shows the relationship between these three activities. The activities are related and combine to form a cycle that spins as a continuous process.

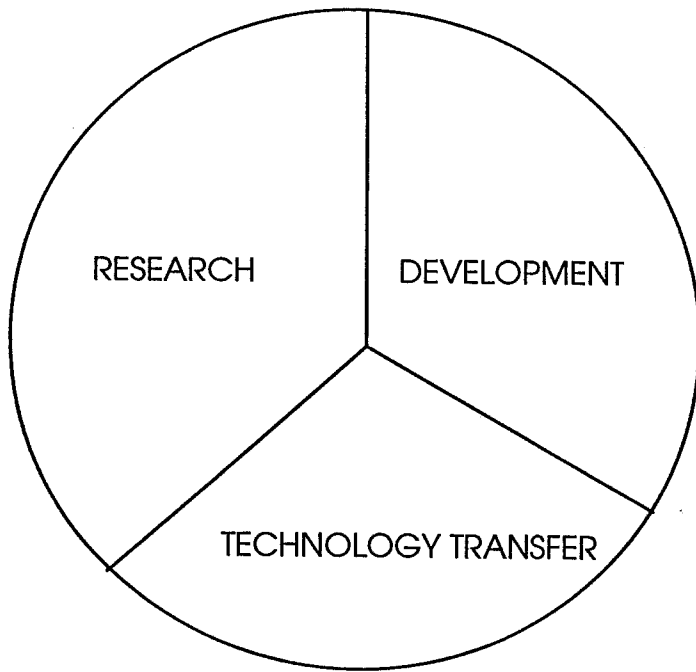


Figure 1. The Innovation Process

The three activities can be further broken down into aspects or types of research, development and technology transfer. The way that the cycle is completed by postgraduate education having a link with fundamental research can clearly be seen if the role of Universities are superimposed upon this evolving picture of a spinning cycle of innovation.



Figure 2. Contributors to Innovation

Other types of organisations that have responsibilities for different parts of the different activities of technological innovation in property and construction IT are shown in figure 2 above. At present the relationships are static although some types of organisation serve more than one innovation activity as the discontinuity of the lines radiating from the centre indicates. Ultimately a range of specific organisations can be seen to relate to IT innovation in Property and Construction. The UK centre of excellence can be seen as a spinning cycle of innovation activities surrounded by an organised framework of organisations. Each of the types of organisation in the outer two rings of the picture can be seen to link with all parts of the spinning cycle of activities in the inner two rings touching with them and thus both drawing from and contributing to the process.

7 AIMS AND OBJECTIVES OF THE UK CENTRE OF EXCELLENCE

The aim of the UK centre is to co-ordinate ongoing research within IT in property and construction. The purpose of co-ordination is to focus the activity and to ensure that it is most effective by most productively exploiting available expertise and resources. The goal is to ensure that all innovation in property and construction IT is focused on the improvement of productivity and quality. The realisation of these aims will be achieved by targeting the following objectives for IT in UK property and construction:

- to contribute to the definition of a national IT strategy.
- to gain and define an overview of ongoing research expertise and projects.
- to elicit knowledge of research needs and priorities.
- to act as a brokerage facility in matching needs with expertise.
- to encourage the definition of standards and policies that support the development of practical and useful tools.
- to encourage the concentration of research in best academic and industry practice.
- to accredit and endorse good research.
- to maximise dissemination effectiveness through technology transfer.
- to act as a focal point for international networks by promoting collaboration.
- to liaise with other innovation initiatives in the UK and feed to them the needs and requirements of property and construction IT research.

8 THE BENEFITS

The benefits to the allies will arise from the opportunity:

- to be part of an expanding industry focus for IT
- to participate in joint developments within the industry with access to other interest groups
- to ensure that existing professional knowledge bases are enhanced within an IT environment

- to ensure that professional and inter-professional roles and relationships are recognised within a deregulated and re engineered construction process
- to set standards
- selectively liaise and participate with a range of Property and Construction IT initiatives

We can illustrate the importance of some of these potential benefits with some of the following quotations:

" The traditional structure of the construction industry causes a waste of key resources, encourages delay and additional costs and can obstruct the free flow of information vital to a construction project. A new structure is called for that sets all parties a common goal of fast, economical construction of the required quality and will enable the UK to compete effectively in future markets." (NCG, 1988)

" Information flows in construction will increasingly be made electronically, and tools for Quantity Surveyors need to be developed alongside other systems for construction." (RICS, 1991)

The benefits for corporate participants would include the opportunity:

- to be part of a group which will be the focus for information about new ideas and products
- to ensure that technology transfer is given a central place within the IT research and development processes
- to ensure that a formal link exists between IT users and producers
- to exploit shared visions in setting strategies and formulating, assessing and implementing policy
- to participate in pre-competitive research and development with shared costs
- to gain access to a range of consultancy advice
- to expand existing industry collaboration
- to introduce practical and "real world" influences into a wide range of research and development work
- to strengthen existing influences in the industry using another channel
- to enhance the potential to obtain funding by being part of an industry-wide community of respected organisations
- to speculate at arms-length in leading-edge technology

Again we can illustrate the importance of some of these benefits with industry quotations from the UK:

" A framework is needed to help the construction industry derive maximum benefit from new technology. This includes regulations and standards, research and education, and support for users rather than just developers, of technology." (Building Centre Trust, 1991)

" The central message.. is that consultants and contractors of all sizes can profit from the management of innovation, at little additional cost. The challenge of profiting from innovation lies in harnessing ideas and technology efficiently and routinely for competitive advantage." (CIC, 1993)

9 THE UK ALLIES

The following organisations are those whose status and expertise in the area, and interests in promoting the centre, have led to them emerging as allies in the early stages of this UK initiative. Each has a different role to play and contribution to make. They all bring different expertise, and current property and construction IT activities, to the centre. This early list of allies is not restrictive and others may be able to join as allies at a later stage. This small group has emerged as those core members whose task has been to support the formation and launch of the centre.

Building Research Establishment - *Technology Expertise/National Strategy*
Construction Industry Computing Association - *Technology Transfer*
Construction Industry Council - *Inter-Professional Integration*
Department of the Environment - *Government Standards/National Strategy*
EDICON - *Existing Collaborative Efforts and Experience*
CIBSE, CIOB, ICE, RIBA and RICS - *Major Interest Groups*
University of Salford - *Research, Education and Technological Expertise*

The above organisations do of course retain their own independence within their individual spheres of activity but share a common vision of the need for co-ordinated action. As allies of the centre they contribute their individual activities to it and combine to undertake joint activities that otherwise would not be possible.

10 THE CORPORATE PARTICIPANTS

Although the above are the allies, they are only indirect beneficiaries. Those being served by the UK centre of excellence are all those associated with the production, management and use of property and construction from designers, owners, contractors, to users and occupiers. These constituencies will benefit from a more productive and better quality property and construction sector achieved through increased innovation in the use of IT.

The corporate participants benefit from improving the quality of commercial services available to them to serve the needs of property and construction organisations and users and occupiers of property. This again arises from making well-informed technological investments that would be protected by being continuously updated of the way that IT, and its Property and Construction implications, are developing and becoming both more complex and important.

11 WHAT THE CENTRE DOES

The role of the centre is to co-ordinate the current disparate research efforts in IT in Property and Construction. It will formulate cohesive research and development policies for implementation by governmental, professional and corporate decision-makers and ensure that these conform to a coherent national

strategy. A contribution to the drafting and maintenance of this national strategy is a key activity of the centre.

It will initiate new activities within the IT in Property and Construction field that could not be envisaged by an individual member. In doing so it brings an end to the current scatter-gun approach that was being followed in innovation in this area ensuring that our efforts are better targeted and thereby conserving scarce resources for more meaningful contributions. The importance of such a co-ordinated effort to the UK government can be illustrated by the following quotation:

" A high-quality, well-targeted research programme is a must for a healthy industry. But the competitiveness of the industry can only be improved if such research is correctly applied. (DoE, 1993)

Within this broad mission, the portfolio of activities of the centre includes the following, structured under the three broad innovation areas of research development and technology transfer.

11.1 RESEARCH

- matching research expertise with need as a broker service
- encouraging research collaboration
- undertaking basic research and applied research and development
- undertaking best practice surveys and case studies
- conducting technology foresight activities

11.2 DEVELOPMENT

- accrediting and approving research outputs
- policy formulation
- product development and implementation
- key technology development efforts

11.3 TECHNOLOGY TRANSFER

- research dissemination
- international outlooks and connections
- technology awareness seminars and conferences
- consultancy
- postgraduate courses and short courses
- maintaining research and publication databases

Clearly these are not all possible in the short term and a prioritising of these activities is an important part of the centre's early work. The outputs from these activities will be varied and will include reports, endorsements to products, services, courses, meetings, newsletters and publications.

" Most of the IT needed by the industry already exists but there are some major obstacles to its use: the lack of appropriate standards, difficulty in accessing relevant data, concern over quality assurance and validation of data, and the lack of training and awareness of IT applications." (Building Centre Trust, 1991)

12 LESSONS FROM AND FOR OTHER COUNTRIES

An example of a similar initiative to the UK centre, which is now well established in North America, is the Centre for Integrated Facility Engineering (CIFE) based at Stanford University. This is a venture jointly promoted by the Civil Engineering and Computer Science Departments of the University which has the collaboration and support of major US and Japanese contractors (Teicholz and Fischer, 1994). Other international groups active in this area include a consortium served by CSIRO under the direction of the Department of Trade, Industry and Regional Development of the Australian government (Leslie and McKay, 1993). Many of the ideas used in the formation of the UK initiative have drawn from these other experiences.

Lessons for other countries are of the need to consider whether a similar initiative is appropriate to or required by them. This requires assessing the current state of progress within IT in property and construction nationally and deciding where the focus for further improvements in innovation lies. The opportunity to form collaborative ventures between different types of organisation can then be considered.

13 THE NEED FOR A EUROPEAN INITIATIVE

There is a growing consensus of the need for European collaboration in this area. One possibility is that the UK centre may combine with groups in Finland (VTT and RATAS), Sweden (IT-Bygg), the Netherlands (TNO and Delft), France (CSTB) and others. These could be developed with the intention of forming a European network under EU Fourth Framework funding. The scope for sharing of expertise and knowledge on an international and Pan-European basis brings its own problems and issues but in the longer term may be of even greater consequence as property and construction activities become increasingly internationalised.

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