

# THE USE OF THE INTERNET FOR ENHANCED KNOWLEDGE MANAGEMENT IN THE CONSTRUCTION INDUSTRY

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As extranet and video conferencing technologies become increasingly accessible and affordable, the possibility arises of globally-based virtual organisations entering and operating in geographically-remote, knowledge-driven, markets – a globalising of competition by virtue of the elimination of regional and national communications barriers. The paper commences by considering the possible future implications of this for the delivery of knowledge-based services at distance. It then discusses whether such developments in virtual working represent a threat or opportunity for the professional knowledge-based sectors of the Construction Industry. It also considers the potential implications for the way of working of the Construction Industry and its global supply and consumption of knowledge-based services and research. The paper speculates whether the prospect of increased availability of standard services by virtual means will be matched by the globalising of the market for non-standard professional services delivered-at-distance by electronically-enabled virtual teams. The paper concludes with recommendations for a research agenda on knowledge-based e-Construction issues.

Keywords: built environment, e-business, professional services, virtual working, knowledge management, internet.

## INTRODUCTION

The knowledge-driven economy is here, now, and knowledge management appears to have become the new differentiator of competitiveness. Across the economy as a whole, innovative businesses are operating in an increasingly information-intensive manner, using knowledge and technology to enhance the management of their core process, the way in which they use their business support capabilities, and their management of supply-chains and customers. As the pace and complexity of the operation of individual economies increases, also their inter-activity and inter-dependency, so the application of knowledge becomes progressively more pivotal to the success of every business. This paper considers the scope and implications of the Internet to enhance knowledge management for the benefit of the construction process and the construction industry as a whole. It concludes that a range of inter-dependent advances, requiring new research, are required to support and sustain the use of the Internet for enhanced knowledge management.

## THE KNOWLEDGE REVOLUTION AND THE CONSTRUCTION INDUSTRY

Consider first the impact that the knowledge revolution is having on the construction market. There are a number of external drivers, not least of which is the changing business use of operational property. Witness the moves in the high street and banking operations away from an operational reliance on buildings. This is also occurring with other sectors of the economy, as they review the focusing of their core process and product or service delivery strategies around a dependency on buildings. For instance, *supermarkets*, where there is intense competition to dominate the internet shopping market; the *financial services* and *insurance* sectors; high-street stores, and a range of other knowledge-based service industries including *higher education*. However, beyond this changing demand profile in the newbuild and refurbishment markets, there is a deeper and more pervasive change occurring within the Construction Industry itself, the implications of which are multi-faceted and probably irreversible.

First and most obviously, the speed at which client needs *can* be changed using modern electronic design processes and e-business communications are challenging the existing managerial processes of designing and constructing buildings; and highlighting the limitations that the existing approach to these processes impose on clients (Kagioglou et al, 1998a/b, 1999). Coupled with the extra volatility that e-business markets are bringing to the client side of the business, these rapid changes in construction demand profiles look likely to further destabilise the already-volatile business climate, and business processes, of the Construction Industry.

Secondly, consider the globalising effect that e-business is having on the knowledge-based service sectors within the Construction Industry such as design, project management, and facilities management. As technology allows knowledge to be sourced and delivered at-distance, the traditional geographic confines of the knowledge-based portion of the construction market disappear. Procurement and the delivery of these knowledge-based services are increasingly operating in a global marketplace, and, by virtue of the technology, the barriers to entry are dropping as new markets are appearing. Examples of the global sourcing or team working on professional processes such as structural design have indicated the cost pressures of overseas provision of defined professional services electronically. Group design working is also taking-off, and initiatives in computerised quantity surveying, price forecasting, and engineering design are affecting regional and national market stability for professional services by combining specialist IT provision with electronically-enabled delivery over distance. In the more established field of specialised IT programming, the consequence is a globalised '*dutch auctioning*', where consultancy services estimated as costing \$100k in the US, but available in the UK for under \$20k, were procured *and* delivered *virtually* from Belarus through a specialist internet agency - for \$2k (Grande, 2000).

## VOLATILITY AND CHANGE IN KNOWLEDGE

Another aspect of these changes is the volatility of knowledge. New knowledge is a scarce commodity, difficult to create, frequently short-lived, and risky for those who attempt to exploit its first-to-market advantage. Like existing knowledge, it is also easy to lose. This is why knowledge creation, knowledge management, knowledge retention, and knowledge re-application are central to business competitiveness and innovation in a knowledge-based economy (Davenport, 1993).

Losing or failing to capture and re-apply knowledge is no longer a non-core issue for the Construction Industry, since in a knowledge-based economy it is becoming a principal competitive differentiator. Sir Clive Thompson's comments in his 2000 Presidential new year message to the CBI indicated clearly that there is little choice about participating in the knowledge-driven economy: "firms must adapt to survive in the new UK.com ... companies will have to be more creative. They will have to bring in new products and services to achieve growth and retain margins. Innovation will become the industry watchword of the 21<sup>st</sup> century". So, where do the threats and opportunities of a knowledge-based economy lie for the Construction Industry, and will these advances in the technology of communications amplify its strengths, or simply its weaknesses? (Hammer, 1990).

## **DOING THINGS DIFFERENTLY, OR DOING DIFFERENT THINGS?**

Bearing in mind that design and construction management are knowledge-based activities, any developments in the technologies which enable remote knowledge delivery have the potential to interfere with the dynamics of marketplace. The same holds true for remote sourcing of expertise, which is essentially an 'internal-to-the-construction-market' supply-chain phenomenon. Whilst the professional barriers to entry will protect the service offered by core professions (even in a global sense), no longer will distance be a barrier to competition within regional sectors of the industry.

First is the effect that advances in IT could have on where, and in what form, the 'added-value' of the professional service appears. The increasing capability of specialised construction IT (structural design packages, for example) means that, in time, the traditional professional inputs to standard design solutions could become marginalised to verifying computerised design solutions outsourced abroad more cheaply (Aouad *et al.*, 1999)? New sources of added value will have to be found, which set alongside the trend to standard general building design will be challenging.

Second, if this sort of development was to occur on a significant scale, there would be a secondary and perhaps more pervasive driver of *financial competitiveness* in a global marketplace. The pressure of reductions in the differentials for the services offered by competing providers would be borne most by professionals in those geographic regions/ industries which responded least rapidly. Another component in this phenomenon may be an increased dependency upon the exchange rates rather than technical capability and delivery mechanisms (Grande, 2000), a frequently-cited driver of overseas investment dynamics in the UK.

One temporary solution may be to operate within global partnerships in order to be able to take advantage of this by sourcing professional services over distance but from within such a partnership. In the short term this may stem the demographic diffusion of the professional market, thereby creating a partially-controlled internalised geographic market (by virtue of regional or national gatekeeping access to projects), but the direct delivery over distance will surely prevail in the externalised free market (Grande, 2000).

Looking to the Construction Industry as a whole, it already has a strong base of existing knowledge about good practice from which to start. Information warehousing and CAD-based archiving and control of facilities management are all potentially possible with current technology and existing data. To-date, the scope of these vast resources of data and information about the design, construction and operation of

buildings have remained rather under-exploited, however. Technological advances are underway, in particular the IAI initiative to harmonise and systematise the protocols for designing and integrating specialised construction IT.

A prime problem is the ownership and handling of dispersed knowledge. This cannot easily be dealt with unilaterally, since it strays into IPR and the boundaries of professional liability. There are examples of project-based applications of IT to provide a unified information system, but the replication and re-application of designs and processes are still a challenge for an industry operating mostly via the formation and dissolution of temporary teams.

However, the technological complexity of co-operation and re-application are but the tip of the iceberg. Putting aside the cultural and legal dimensions to co-operative working across projects, there is considerably less material available about the role of *management processes*. As will be discussed later in the paper, the introduction of the *new* technology is not sufficient without careful attention to the processes which have to co-operate with it (Hinks, 1998a).

Allied to this is a further and perhaps even more important and challenging aspect to these issues. There is a tendency for Construction Industry initiatives to focus their search on finding and communicating better ways to provide the same services, services that do not necessarily represent the full opportunity for the industry to innovate and offer the new, different services needed by businesses operating in a changing economy. Furthermore, as intimated above, it has conventionally been assumed that the challenge lies in capturing examples of best practice on individual circumstances, distilling them into generally-applicable principles, and finally making these general distillations of good practice available for application throughout the breadth and depth of the industry. One of the reasons that the record on application is not good may be the deeper and largely unresolved challenge of how to technologically and managerially attune *general* guidance to the *particular* circumstances of each and every organisation wishing to innovate (and to do so in the absence of any local support or feedback).

## **COMMUNICATIONS TECHNOLOGY AS AN ENABLER OF CORE PROCESS CHANGE**

With the emergence of modern extranet and video conferencing technologies, the communication and process support technology required to underpin innovation in today's construction market is becoming more accessible. This development provides immediate scope to tackle one of these traditional limiters to advancing the industry: the problem of location – firstly the variability of location in the Construction Industry and the difficulty this presents for making centrally-held resources available and usable in varying locations such as construction sites; and secondly the difficulties of capturing, accessing, and re-applying new and existing knowledge on a decentralised basis to a nomadic industry.

Taken together, the improved quality, speed, and depth of communication that these technologies offer - extranets to support the systematic storage and accessing of vast amounts of information; the use of electronically-based value adding processes;

plus video conferencing to facilitate bringing remote teams members together – are being heralded as the new imperative for innovation for the Construction Industry (Knuttt, 2000).

Video conferencing technology offers the industry the scope to collect and send data or information to and from physically remote, perhaps even hazardous, locations. Delivery is 'in person' but at distance, and without the usual delays of travel. The tool allows information to be delivered anywhere in the world linked by the internet or by telephone, with security if required. Remote management and monitoring becomes possible, and it is practicable to economically deliver rare and expensive expertise across distance with minimal response times, also to hold multiple-location, multiple-person team meetings at minimal notice. One of the major cited savings is in reduced travel time and cost (Knutt, 2000).

Whilst extranets appear to offer the scope to manage the information needs of physically-dispersed teams, particularly the sorts of problems that can arise with rapidly-changing versions of documents, or ensuring that all team members have secure access to only the necessary information for them, at the same time and with minimum of delay, the reality is likely to be more complex. Consistency in processes and technology (including software) are pre-requisites (which may be a significant assumption still for the Construction Industry). Examples exist already of round the clock shift working on design projects using experts working in relay around the world (Kagioglou et al, 1998a/b). The communication of specifications, design details, and as-built details are all thought to be manageable using extranets. As mentioned earlier, though, without an underlying protocol to orchestrate these communications, the technology itself is unlikely to resolve any existing problems.

## **MOBILITY AND THE GLOBAL CONSTRUCTION INDUSTRY**

Meanwhile then, the great novelty for the Construction Industry may lie in how the emerging communications technologies affect competitiveness and operation within the global Construction Industry. A mobile industry normally, the scope to access and co-ordinate project information via virtual project databanks and extranets could revolutionise the conventional problems with centralised communication and control of construction projects. Thus applied, the technology could open up a new set of marketplace opportunities in an industry that has traditionally had relatively low barriers to entry and has survived by virtue being regional or national. Driven by the impatience of clients for better quality buildings, on time, and to cost and quality expectations, the use of information technology to bring the industry into the knowledge-driven age will surely occur, even if it occurs as a development in niche areas first.

The obvious outcome of this is the potential to increase the speed and accessibility of expertise. There is a larger issue of the scope the IT brings to deliver and receive professional and managerial services from great distance, however. Is it unrealistic to consider whether a high value part of the construction management function could start to be delivered from distance? If so, the implications of getting it wrong as a national industry in a global market are suddenly much more vital. Is there a risk of sectors of the industry coming under market pressure from overseas service providers operating via the creative use of IT? Refer Grande on IT from Belarus again (2000), and consider the possible futures from an operational and strategic level.

## **OPERATIONAL CHANGES AND THE CONSTRUCTION INDUSTRY**

Looking at the operational level of how the construction industry works, there are great possibilities of technology-driven changes in how the industry accesses knowledge, co-ordinates it, and communicates internally. The design and construction process is becoming ever more dependent on rapid and high-quality communications between teams working to tightening time scales and a backdrop of ever-higher quality expectations of their clients (Kagioglou et al, 1998a/b). And as access to knowledge becomes more central to co-operation in professional teams and to the business competitiveness of the individual firm, so the successful linking of the right knowledge with the right people at the right time will become pivotal in process competitiveness.

Extranets may allow the intelligent and secure storage and flexible communication of project information in a way and on a scale not before practicable - so tackling one of the timeless problems of communications within the industry (Knutt, 2000). Again, the communications technology can only support advances in process control and consistency – not substitute for it! With secure access to information and instantaneous availability anywhere through electronic delivery from the extranet, round-the-world-round-the-clock working on design projects is immediately possible and has been explored already in the Civil Engineering sector (Aouad et al, 1999; Knutt, 2000).

Video conferencing appears to offer even more significant opportunities for the industry. Flexible video conferencing communications across distance offer the prospect of physically-dispersed teams to communicate as virtual teams, and providing project managers with the chance to access remote expertise and/or deliver their value-adding services from distance to their clients, anywhere, anytime. Interim meetings or briefings could be convened at very short notice to resolve design or production issues, including the necessary discussion and revision of electronic design information on-line and involving all of the team in the change process.

Remote consulting over any distance could provide access to expertise which otherwise might be uneconomic or less accessible, perhaps even inaccessible. There is also the opportunity to deliver professional knowledge-based services more flexibly than before, ideal when the company expertise is displaced from its potential client base.

Aside from overcoming the practicalities of physically getting to meetings, there is some evidence to suggest that video conferencing technologies can enhance the effectiveness of meetings through the rigour that their use encourages. Meetings become shorter and more focussed. Combining this with the application of extranet technologies that support the secure storage, control over versioning, and rapid access to company or project information, there is much scope to revolutionise the control on projects and the way of working.

Looking beyond the individual project or the delivery of the professional service, the technology offers scope for the on-line delivery of interactive training advice or remote troubleshooting during the installation, commissioning, and/or servicing of services installations. The provision of support services or the collection of feedback on new company procedures as they are put into place could become immensely more flexible, too. Coupled with extranet-based support and on-line document sharing

whilst video-conferencing the scope for interactive briefing or specification development is enlarged.

## **CAVEATS AND POSSIBLE FUTURES**

The Construction Industry has long struggled to capture and re-apply its hard-earned knowledge, and the nature of construction makes it all the more difficult than for the more-conventional process industries making consistent products in controlled conditions. Now the need is more acute than before, since technology is now beginning to offer the means for the innovators with remote access to the worldwide construction marketplace to capture, store, transport, and re-apply their knowledge for competitive advantage anywhere.

Knowledge is the differentiator for the provision of services within knowledge economy. The technology of course is simply the delivery tool. The knowledge revolution clearly has potential to affect several inter-dependent dimensions of the Construction Industry and it's way of working, at a micro and macro scale, and in terms of the nature of services as well as revising their delivery mechanisms and marketplace. And as with other developments in information technology, what commences as a novelty quickly becomes a source of competitive advantage. Soon, not having the technology becomes a competitive disadvantage. Ultimately the implication of the growth in e-business is going to be that those organisations wishing to apply the technology for competitive advantage are going to have to also address their managerial processes (Hinks et al, 1997). So where should the industry focus its research efforts in addressing the opportunities and threats of the knowledge revolution?

## **POSSIBLE FUTURES AND RESEARCH PRIORITIES**

### **Knowledge-Based Markets in Construction**

As a priority, the industry must assess the scope for the knowledge-dependent elements of its core and support processes to be undertaken and delivered as electronic services from distance. This is already appearing as a differentiator in global competitiveness in many sectors, and market infusion at a national level by competitors who were previously unable to compete only because of the cost of entering or by virtue of operating from distance are a risk or opportunity that should be considered by all. These types of consideration also have to be extended to the integration of supply chain processes, since global and virtual procurement can operate vertically as well as horizontally.

### **Communications and Delivery of Professional Services from Distance**

The first wave impact on the Construction Industry is likely to occur in the areas that have already been the focus of considerable developments in specialised IT. Noticeably this is the area where rapid and significant changes in the necessary managerial process capability appear to have been most readily grasped in the industry (Hinks et al,1997; Aouad et al, 1998). Much of this is in the high-value professional core of the Construction Industry, where these new advances in communications technologies could threaten the traditional geographic boundaries to the delivery of professional services. A failure to address this market potential at the level of individual organisations and the industry as a whole could leave the professional sub-sectors of the Construction Industry open to erosion by competitors who do.

Correspondingly, there is a potential market for those who can deliver more economical or value-adding services from distance.

### **Specialist Services Delivered Electronically**

The more globalised the construction marketplace becomes, the more global are the sources of expertise that have to be brought together to achieve complex projects. The ease of integrated working within and between professions is likely to spawn information-centric specialist services that will address one of the traditional weaknesses of the industry and take a significant element of the project management function. The result could be an amalgamation of the major IT-supported industry players, produced by a stratification of the industry based on the emergence of management and delivery of knowledge-based services from a virtual (and global) platform.

### **Global Consortia and Global Mobility**

In a similar context, Internet-facilitated developments in the specialist supplier markets in engineering indicate that globalised consortia or buyouts can be effectively and efficiently coordinated to gain significant customer market growth. If properly recognised and harnessed, the prior experience of fluid team working in the construction industry (which has been akin to virtual team-working without the electronic underpinning which is now available) places the industry in a very powerful position to avoid an element of the learning curve which other industries will have to face.

### **Cross-Border Sourcing**

The sourcing and delivery of professional services virtually is a potentially major new sector for the industry, and should be considered on an international or global scale, particularly where significant currency differences create competitiveness pressures for essentially generic services and products sourced globally (Grande, 2000). Individual companies will need to consider cross-border strategies for sourcing and final supply of professional and other industry services.

### **Knowledge Management**

The delivery of end-user services and core processes/ sub-processes need to be carefully orchestrated with process management (Hinks, 1998b). This is an enormously complex issue involving ways of working, also the re-generation and sustainability of competitiveness in knowledge-based functions which themselves are going to require refreshing with emerging knowledge in order to maintain competitiveness in their capability. For many organisations, this will involve complex initial transition management for their own processes, and an ongoing commitment to incremental process change (Hinks, 1998a/b).

### **Integrating Technology and Process**

Underpinned by existing industry-wide knowledge of logistics management, supplier relationships, and nomadic production know-how, there is great potential to embrace the scope offered by the technology. The cultural challenge for construction lies in the uptake of IT and (more so) its meaningful integration with the core managerial processes that it expects to offer as a value-adding service (Allen et al, 1994). These processes need to be mapped beyond the point of repeatability in order to allow the IT and knowledge management to be attuned to a defined and manageable process (Davenport, 1993; Martinsons, 1995; Remenyi et al, 1997; Hinks et al, 1997; Hinks



1998a/b). The technologies place an ever-greater emphasis on co-operative working across and down the industry chain.

### **Research and Knowledge Supply**

The likely outcome of a price-driven market for virtually-delivered *standard* professional services is going to contrast with the scope for innovative services and specialist *non-standard* design services to be offered globally by those organisations with the capability and reputation to deliver innovative design solutions. For example, automated remote data analysis is already commercially available for performance assessment against the UK Movement for Innovation (M4I) Key Performance Indicators (KPIs) for Construction, and remote construction site progress monitoring has been facilitated using a combination of Telepresence and Virtual Reality (Retik, 2000). The opportunities to offer remote, knowledge-based services is probably where the really high value work is going to emerge on a globalised marketplace. Supplying this market with cutting-edge knowledge and expertise will be an essential service for competitiveness.

### **Technological Barriers to Industry Take-up**

There remain technological blockers to the full economic attainment of the potential offered by the technology. Effectiveness may be a more relevant issue than cost-efficiency in the turbulent start-up period. Bandwidth remains a problem, and the call costs for global video conferencing are still prohibitive. The capital investment in video conferencing can also be barrier to entry for small enterprises (80% of the UK Construction Industry), and integration of supply of specialist services needs to be considered in conjunction with a supply chain management strategy which will have to include this sector of the industry.

### **M-Commerce and the Construction Industry**

As accessibility to extranet and video conferencing become realistic using mobile WAP-based (wireless application protocol) communications technologies, the potential for the industry is immense. Ultimately it is insufficient to simply apply IT without a corresponding attention to process capability (Hinks et al, 1997, 1998a/b); and this requires a consistency of application within each organisation, led from the top down. A wider resonance in the technological and cultural farsightedness of the industry is needed, and this can only really be orchestrated through pan-industry initiatives such as the UK M4I initiative.

It is not clear yet where the actual and promised changes will differ, however. There may be many False Springs. Overall however, the effect of *The Death of Distance* will be to elevate virtual working beyond a support technology to a strategically-critical competitive lever for the Construction Industry.

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