The application of information technology by Australian contractors: toward process re-engineering

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ABSTRACT

Information technology (IT) has been advocated as the key enabler of process re-engineering in the construction industry. Process re-engineering represents a philosophy of change which embraces a fundamental paradigm of rethinking and redesign of processes, including lean construction. Its potential application to the construction industry is gradually being recognised. The management of processes invariably requires information, and therefore the capacity for IT to enable process re-engineering in the construction industry needs to be investigated. However, it is suggested that before the potential benefits of IT and process re-engineering can be realised, current work practices need to be explored.

A recent survey of 47 contracting companies' current and future applications of IT and the benefits and problems associated with its implementation are described. The results obtained suggest that advanced applications of IT such as simulation, expert systems, and supplier direct-link ordering were limited in their appeal to Australian contractors. This paper concludes that contractors do not foresee IT as having a significant impact on their current work practices, although it is suggested that contractors are possibly not aware of its potential application. The implementation of IT as the key enabler of process re-engineering is discussed.

Keywords: information technology, process re-engineering, process, enabler.

INTRODUCTION

The construction industry, like manufacturing and several other industries, is confronting a crisis of restructure which is founded on rethinking and focusing on reforming current production processes and workflows, with the aim of adding value to the production process and the product. Implicit to this is the role of new technologies. Yet, a thorough understanding of communication and information processes practiced within the construction industry is not known. Consequently, the CSIRO Division of Building, Construction and Engineering embarked on a three-year research program to investigate the application of process re-engineering and the role of IT in the construction industry. This paper describes some the findings of a pilot survey that was undertaken in regard to:

- the current and future applications of IT; and
- the benefits and problems associated with the implementation of IT.

This paper provides background to the communication problem that exists in the construction industry; a definition of process re-engineering; the findings of a survey on the current and

future applications of IT; the benefits and problems associated with its implementation in the construction industry; and a discussion of IT as an enabler of process re-engineering.

COMMUNICATION IN THE CONSTRUCTION INDUSTRY

The construction industry is heterogeneous in the nature of its organisations. Consequently, to procure a construction project, a variety of organisations are typically combined to create a 'temporary multi-organisation' (TMO) (Cherns & Bryant 1984) to discuss and exchange information. However, because of the fragmented nature of the construction industry, no single organisation can dictate and therefore be responsible for establishing and maintaining the necessary communication networks for a construction project. Consequently, the industry is faced with ineffective communication and information processes which have inadvertently contributed to project cost and time overruns. For projects to be successful, the participants of the TMO must communicate and exchange information more effectively (Alty 1993).

As the construction industry is information-intensive, creating and sharing information is an inevitable exercise on construction projects. Typically, time is wasted on locating the appropriate information or providing redundant information, e.g. document duplicating, rewording, too much information for individuals to consume, and insufficient information for critical decisions. Furthermore, there is a general perception among researchers and industry practitioners that poor communication is primarily responsible for the undesirable but existing feature of rework.

For many years, the construction industry has been criticised for its fragmented nature which has ultimately contributed to ineffective communication practices between project participants throughout the construction process (Emmerson 1962; Banwell 1964; Higgins & Jessop 1965; Latham 1994). Higgins and Jessop (1965) identified the fundamental reasons for the construction industry's communication problems. The raison d'être for their research was to obtain a greater awareness of the difficulties of communication that often arose between various organisations when they were commissioned to procure a construction project. Higgins and Jessop (1965) suggested that to improve the communication between project participants, new models of the building process that better meet the criteria of operational effectiveness, the appropriate location of control and responsibility in the role structure should be implemented. Their report and subsequent reports such as Latham (1994) suggest that communication difficulties in construction still prevail.

Ndekugri and McCaffer (1988) suggest that 'in spite of this amply demonstrated awareness of the communication problems, the solution has, by and large, continued to elude the industry'. The need for effective, reliable and timely communication in the construction industry has never been greater. Even in 1986, Ibbs (1986) supported this proposition where 'at a meeting of important construction experts in 1985 it was decided that the underlying issues of the information flow process in the construction industry were not properly understood and therefore needed urgent research'. Thus, the mere application of IT to the existing organisational processes of the construction industry will not solve the inherent communication problems that currently exist. If the construction industry is to improve its communication and information flows between project participants and simultaneously reap the potential benefits of IT, then existing processes should first be re-engineered.

PROCESS RE-ENGINEERING

The traditional management concepts of organisation and the labour division may be considered to be no longer applicable in a world of global markets, changing customer requirements and rapid communication. The recipes for change, commonly known as re-engineering, kaizen (Japanese for continuous improvement), and total quality are based on the same primary assumption: organisations will have to refocus on their basic task, satisfying customer needs (Hammer & Champy 1993; Davenport 1993; Creech 1994). Even though the means for achieving change differ between the approaches, they share a commonality: a focus on processes instead of functions. The construction industry is slowly taking steps toward a process approach through the adoption of a total quality approach. Yet, other manufacturing industries have considered the kaizen and quality approaches to be inadequate as they are primarily concerned with existing processes and do not meet the increasing needs of the customer.

Process re-engineering can be defined as 'the fundamental rethinking and radical design of business processes to achieve dramatic performance improvements in critical and contemporary measures of performance such as cost, quality, service and speed (Champy 1995). Organisations are addressing the need to remain or become competitive through dramatic improvements in quality, cost, time and service by attempting to reinvent themselves, and by organising work around processes. Process re-engineering, typically focuses on:

- leadership and guidance from top management;
- becoming customer focused;
- understanding why and how processes can be improved, and process benchmarking;
- identifying appropriate tools and techniques for redesigning work processes to meet strategic performance goals;
- implementing information technology to enable improved performance;
- applying effective change management to adjust the culture of the organisation; and
- implementing continuous improvement (kaizen) methods to sustain improvements.

The construction industry has been heavily criticised for its low productivity and poor performance, and is under increasing pressure to improve productivity, occupational safety, working conditions, the quality and value of the final product, and the efficiency and effectiveness of its processes. By re-engineering the construction process, design and construction time is expected to be substantially reduced by eliminating the non-value-adding activities which contribute to ineffective communication and information practices.

The principles of process re-engineering have been primarily based on the innovative use of IT, although to create a new process requires more than the creative application of IT. Recent research, focusing on IT applications in the construction industry, have created new possibilities for more effective communication, data accessibility, and shared information between project participants (Newton & Sharpe 1994). Information technology can no longer be viewed as an enhancement to traditional business procedure, but rather an innovative agent that enables new and different alternatives to organising and operating business enterprises (Ahmed *et al*. 1995).

INFORMATION TECHNOLOGY

There is an abundance of rhetoric amongst industry researchers about the urgent need for construction organisations to introduce information technologies into their organisations if they are to remain competitive, with stress being put on the possible technical opportunities that are provided by the new systems. By way of contrast, however, there has been little concern about the social and organisational options associated with the new work systems.

Numerous researchers in the construction industry have idiosyncratically assumed that IT is the driver or the key enabler of process re-engineering, disregarding the most important enabler of all – people. The use of IT as the key enabler is rarely sufficient to bring about process change (Davenport 1993). Few industries are not affected significantly by developments in IT and there are few organisational functions not transformed by its implementation. Recent research by Scott–Morton (1991) indicates that the implementation of IT may affect an organisation by:

- changing the nature of the work;
- integrating business functions; and
- transforming competitive forces.

A degree of controversy exists at both the macro and micro levels. At the macro level, the most salient issue is the change in the degree of centralisation of decision making, with related questions about the depth and shape of organisational hierarchies. Whereas, at the micro level, the most salient issue is the job definition and content, with related questions about communication patterns, job satisfaction of employees, and skill requirements. There is a remarkable degree of disagreement on the impact of IT on organisations:

- Decision making – IT may increase centralisation because it increases the information processing capacity of managers, hence allowing them to centralise more decisions (Zuboff 1983; Pfeffer & Leblebici 1977). IT may decrease centralisation because it reduces the cost of communication and coordination, thus allowing decisions to be delegated (Malone 1987; Osterman 1986; Zuboff 1983).

- Organisational hierarchies – IT may decrease the depth of organisational hierarchies since it automates some of the middle management functions, facilitating the movement of information through the organisational hierarchy (Crowston *et al.* 1987). IT may increase the depth of hierarchies by reducing the delays and distortions introduced by the movement of information through the hierarchy (Pfeffer & Leblebici 1977; Blau *et al.* 1976).

- Job satisfaction and skill – IT may reduce job satisfaction and diminish skill requirements by: routinising work, subdividing work into small, highly specialised and repetitive tasks, subjecting humans to machine control; replacing low level clerical jobs with high-skill professional jobs; and automating the most mundane tasks (Attewell & Rule 1984; Zuboff 1983).

Information technology can enable great improvements in the collection, storage, analysis and transmission of information. Ensuring that the right information is available, at the right place and right time may be a major organisational undertaking requiring substantial redesign of existing information processing systems, as well as organisational structures.

Recent research suggests that re-engineering that is IT-focused has a high failure rate (Bashein *et al.* 1994). This is primarily because people resist change (Reger *et al.* 1994), as IT is typically introduced as the driving force for re-engineering without any prior consideration to other key enablers. Organisations will continue to experience difficulties implementing change until they learn that people resist not change per se, but the way they are treated in the change process and the roles they play in the effort (Berry 1994).

Bearing in mind the high failure rate associated with IT-based re-engineering, the construction industry should learn from the mistakes of other industries where re-engineering has proliferated to epochal levels. Better understanding of communication and information flows of the construction industry before redesigning processes and implementing IT is necessary.

SURVEY

During October 1995, a survey of the communication and information flows and the use of IT by 47 construction contracting companies was conducted throughout the Australian States of Queensland and Victoria, as part of an overall study which investigated communication and performance practices of construction contractors. The survey had the overall objectives of:

- examining the communication and information flows within contracting companies and between other industry professionals;
- assessing the potential for implementation of IT in construction; and
- investigating the usage of performance and productivity measures for construction projects.

The first stage of the survey related to the profile of the organisations; and the second stage a structured interview. The research was planned as a pilot study and the sample was chosen to give a selection of companies representing small, medium and large contractors. It was considered that less than 20% of Australian contractors undertake more than 80% of the work, and therefore an attempt was made to involve as many of the largest companies as possible, although a few medium and small companies were also included.

The annual turnover of the contractors sampled ranged from less than $A5 million to over $1 billion, while the type of work undertaken ranged from the construction of schools to the refurbishment of multistorey office blocks. The contractors targeted were those involved in construction and engineering, and house builders were deliberately excluded. It was considered that house builders form a separate and somewhat homogenous group which follow markedly different construction procedures, project acquisition methods and use of IT. Eighty contractors were initially contacted (33 in Victoria and 47 in Queensland). Follow-up telephone calls were made to investigate the contractors' interest in the research, resulting in 66 contractors expressing interest in the research (25 from Victoria and 41 from Queensland). For those contractors interested in participating in the study, arrangements were made for interviews to be conducted in the form of a questionnaire. Due to time constraints and workload of several contractors, only 47 in-depth interviews were undertaken (21 Victoria and 26 Queensland).

SURVEY FINDINGS

The communication and information practices survey had a section that specifically addressed IT. The survey's questions relating to IT were divided into two sections: hardware and software. Furthermore, the use of IT at both organisational (head office) and project levels (on site) was investigated. Questions focused on a wide range of technologies, i.e. mobile telephones, personal computers (PCs), laptops etc.

In addition to the information obtained from the questionnaire, informal comments during the interviews were recorded. This information in some cases strengthened the results recorded and in other cases qualified or provided conditional constraints on the responses received, e.g it was discovered that many contractors did not understand what was meant by a knowledge-based expert system. Moreover, there was confusion with the terms e-mail and fax; the difference having to be clarified on several occasions.

Current and future investment in information technology

Many contractors found it extremely difficult to give accurate data about their hardware and software applications. Research and development in IT were limited to a few organisations, primarily with a turnover of over $A400 million. Despite the research and development in IT, only one organisation had a specialist IT department.

Few respondents answering questions pertaining to the organisation's current investment in IT had accurate figures, yet each respondent could give a reasonable estimate of the percentage of IT investment between 1992 and 1995. Generally, the investment in IT for each of the following categories was less than 0.6% of total turnover: research and development, training and education, hardware and operating systems. Contractors with a turnover of over $A150 million invested a much greater percentage of their turnover in IT than the smaller contracting organisations. Many respondents found it difficult to predict their future investment in the selected IT categories, and it was suggested by one respondent that they would be reducing their expenditure on IT hardware and operating systems because the prices for computer hardware and software were expected to substantially decrease over the next few years.

The use of hardware

Each contractor identified the forms of IT hardware used at both organisational and project levels. Among the most popular forms of IT hardware were mobile telephones, PCs and laptop computers. At the organisational level (Figi 1), 98% of the contractors sampled stated that they used PCs as their major IT hardware platform and 77% stated that their PCs were linked via a network system. Generally, it was found that those contractors who did not have a network system in place had an annual turnover of less than $A10 million. It was found that one contractor had an annual turnover of more than $A20 million and still used manual systems at the organisational level, although consideration was being given to implementing computing equipment and a network system within the next year. The use of CD-ROM and document scanning were found to be very limited.

At the project level, there were substantial differences in IT hardware usage from the organisational level (Fig. 2). It was found that 96% used mobile telephones, 55% used PCs, and 28% had networks in place on a specific project. Mobile phones were found to be contractors' primary IT hardware on-site, with most contractors stating that mobile phones

had improved their communication and decision-making processes. Several contractors indicated that networks were only used on site when the project was large enough to support a network infrastructure. Most contractors had a desire to upgrade their existing hardware and increase their hardware portfolio in the future, but the financial outlay was perceived to be a setback.

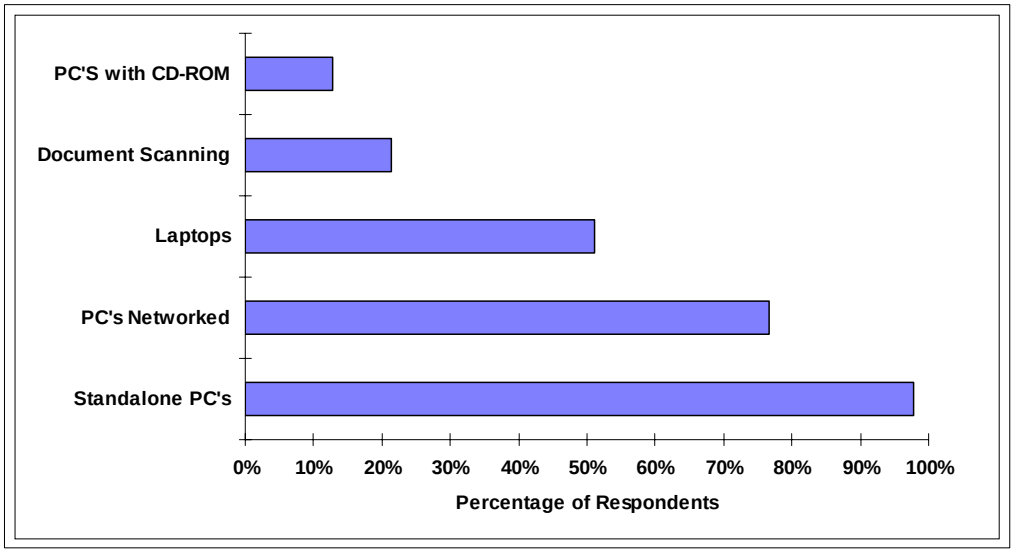

Figure 1: IT hardware – organisational level

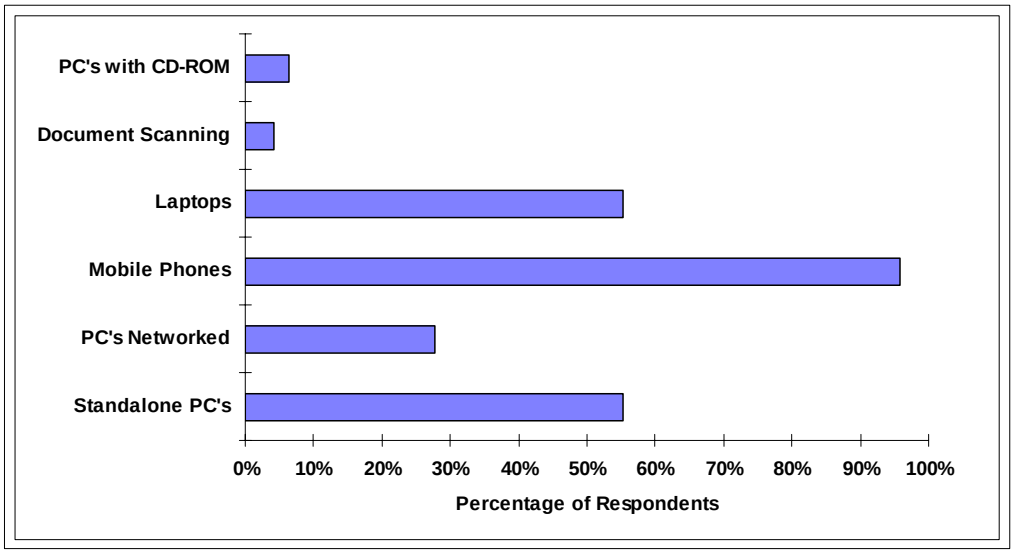

Figure 2: IT hardware – project level

The use of software

The survey revealed that a majority of contractors used mainstream general office application software for word processing, spreadsheets and desktop publishing. A variety of specialist application industry software was used for document control, cost control and reporting, cost planning, estimating, and cashflow forecasting, the most popular being identified in Table 1. Advanced software applications such as those based on knowledge-based expert systems and simulation were rarely used. Computer-aided design (CAD) software (AutoCAD) was found to be used by 15% of contractors. These were primarily the larger contractors with turnovers

in excess of $A400 million. The lack of advanced IT applications appears to be alarming, especially as the role of the contractor is changing with the increase in the incidence of design and construct projects. At a project level, the use of software packages was limited to office administration, cost control and reporting, and document control.

Table 1: Most popular software packages

Function	Software package
Office administration	Microsoft Office Professional
Estimating and cost planning	Buildsoft
Cost control and reporting	Jobpac/Client/Cheops
Cash flow forecasting	Fincash/Excel
Planning and scheduling	Microsoft/Project/PrimaVera/Micro
Document control	Jobpac/Client
Computer-aided design	AutoCAD

Typically, software was upgraded when a modified version of the package became available. Many organisations were reluctant to introduce more advanced software applications, primarily because of the anticipated additional training required and therefore the loss of productivity.

Electronic communication and information transfer

The extent of electronic communication and information transfer was considerably limited to the organisational level for each contractor sampled (Fig. 3). The telephone and fax were undoubtedly the most popular forms of information interchange used by contractors at both levels. While phone conferencing (55%), and fax modems (43%) were frequently used, video conferencing was used by only 15% of contractors and e-mail by 26% of contractors. Primarily these electronic links were used for interstate and overseas communication between offices and used by the larger contractors with a turnover in excess of $A400 million. Communication with subcontractors, suppliers and consultants via electronic means such as fax modems, e-mail, video conferencing and phone conferencing did not occur. Moreover, the use of external information sources via on-line services and the internet were extremely limited.

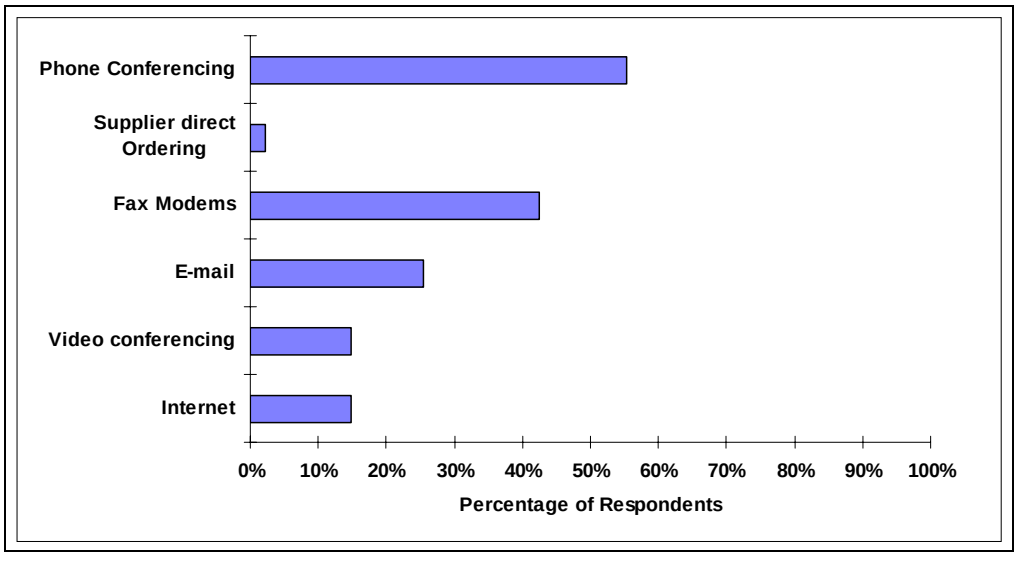

Figure 3: Communication and information sources – organisational level

Problems and benefits associated with the implementation of IT

Each contractor identified the major problems which they had experienced with the implementation of IT (hardware and software). Figure 4 indicates that the most common problems experienced with IT were: the lack of systems knowledge, with 68% of contractors perceiving this to be a problem; and the lack of training associated with its implementation, perceived to be problem with 62% of contractors. Implicitly contractors were unaware of the impact that potential advanced applications of IT could have on the organisation's competitive position. This was found to be the case with more than 50% of contractors using highly specialised planning and scheduling software for simply doing bar charts. This lack of systems knowledge of the particular software meant that in a number of cases planning and scheduling of construction projects was undertaken externally by consultants.

The security of hardware was perceived to be a problem with 28% of contractors. Typically, hardware applications were kept to a minimum on site because of the increasing incidence of theft that had been experienced. This appears to be the main reason for the differential between the use of IT at the organisational and project levels. Environmental conditions were not considered to be problem at the organisational level, but at the project level, keeping hardware away from dust was seen to be a problem for 30% of contractors. Lack of support for users was considered to be a problem for 26% of contractors, all of whom experienced problems relating to a lack of systems knowledge and training.

Generally the respondent being interviewed held a senior position within their organisation. Consequently, it was difficult to ascertain that a lack of management commitment was seen to be a problem for IT implementation. However, there was a consensus amongst respondents interviewed toward the lack of management commitment for the internet, e-mail, and advanced applications such as knowledge-based expert systems and simulation, inasmuch as the respondents (management) lacked education in their usefulness.

Several contractors commented that it was difficult to keep up to date with the advancement and innovations in both technological and software developments, expressing their concern that the economic climate of the industry did not enable them to devote the necessary time and money to follow advancements in IT.

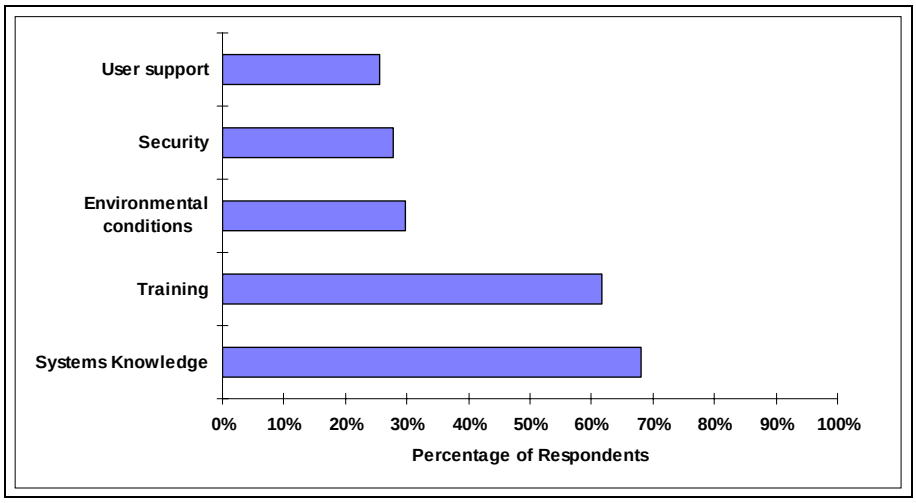

Figure 4: Problems experienced with IT

Hampson and Tatum (1994) suggest that contractors are traditionally accustomed to intense price competition and focus on the bottom line, thus facing difficulties in justifying investments in advanced technology. Other problems mentioned by respondents during the interviews included: considerable reluctance on the part of some employees, who through lack of systems knowledge and understanding did not realise the benefits that may accrue from IT applications; and the loss of productivity from employees because they lacked a thorough understanding of the usefulness of IT.

In contrast to the problems associated with the implementation of IT, respondents identified that benefits were gained in: decision making; productivity; information storage, handling and transfer; and information access and retrieval. For each IT application identified, more than 70% of contractors experienced benefits from using IT.

It is well understood that the majority of construction practitioners are interested in construction management applications rather than what the IT tool can offer (Tucker & Mohamed, 1996). This was made quite clear during the interviews, by practitioners who do not consider IT tools as being an integral part of their decision-making processes.

The perceived future of information technology

Most contractors were only concerned with their short-term survival. When each respondent was asked to indicate the anticipated future requirements and expenditure of the organisation on IT over the next five years, many stated that they expected it to be minimal. Furthermore, most contractors planned on upgrading their existing software, with no intentions of implementing advanced technological or software applications in the short term. Nevertheless, most did recognise that they needed to embrace advancements in IT if they were to remain competitive. Consequently, contractors need to be better educated about the potential applications of IT.

The needs and requirements of the organisation should be evaluated at both organisational and project level along with the usefulness of the technology to be implemented. It is suggested that if IT is not managed in line with an organisation's needs, information processes may become ineffective and consequently impair decision making. The management of construction requires information; therefore it is considered essential that the most effective forms of IT are utilised.

DISCUSSION

The findings reveal that IT has yet to make a significant impact in Australian contracting organisations. The degree of awareness of advanced computer applications like simulation, expert systems and direct link between computers was extremely limited. Electronic mail, for example, was found to be used by only a few organisations and exclusively for internal communication. Furthermore, contractors are unlikely in the short term (within the next five years) to invest and implement advanced applications of IT.

Consequently, advanced technologies may not be prerequisites of process re-engineering. Implementing a network system or databases is seen to be radical for most contracting organisations. Perhaps the most effective solutions for process improvement are the technologies and information management systems of today and not necessarily of tomorrow.

Most contractors recognise that there is a need to identify and exploit the opportunities presented by IT. Similar findings have been found within Australian quantity surveying (Best *et al.* 1996) and architectural practices (Dawson 1994). Typically, Australian contractors have adopted a reactive rather than proactive stance to the use of IT.

Bearing in mind the findings of the survey and the findings of Best *et al*. (1996), the use of IT as the key enabler of process re-engineering at the organisational and project levels in the Australian construction industry is perhaps questionable, at least in the short term. Coulson–Thomas (1994) states that while IT can often be regarded as a key enabler of radical process change, it may not play such a role in every re-engineering exercise. Moreover, it is contended by Coulson–Thomas that a radical breakthrough could result from putting people first and freeing them from constraints imposed by IT. In essence, IT is sometimes the problem rather than the solution.

Whether or not IT is considered to be a key enabler, it has a role to play in the process re-engineering exercise. Perhaps existing forms of IT can be used to radically transform existing processes. Irrespective of the role of IT that is adopted, a degree of pragmatism is required. Other essential enablers must be used in conjunction with IT, these being founded on organisational and human innovations. If contractors are to seek a competitive advantage in the marketplace, improved performance and productivity, then they should begin to take advantage of the technological applications that are available. To assume that IT can be introduced into an organisation without affecting its organisational structure, culture and people would be extremely naive. Construction professionals need to be made aware of how IT can affect their organisations if the benefits of re-engineering are to be acquired.

In a practical sense, process re-engineering attempts to re-optimise organisational processes and structures by introducing IT into an organisation. Yet anecdotal evidence suggests that even small changes in the use of IT may require major restructuring of the organisation (Hammer & Champy 1993; Hammer 1990; Barley 1986; Hackman & Oldman 1980). Conversely, there is evidence to suggest that without restructuring, the introduction of IT may not produce the savings needed to justify its investment (Panko 1991; Pfeffer & Leblebici 1977). Although the evidence for organisational restructuring to accompany technological change is strong, there is much less agreement on exactly what organisational changes are needed to take full advantage of the technology.

If IT is to play its part as an enabler of fundamental change, the contractor's IT administrative personnel must be prepared to take up the challenge, taking into account the effects that IT will have on the organisation.

CONCLUSION

Developments in IT have the potential to affect business strategies, organisational structures, and management processes in contracting organisations but findings from the survey reveal that construction contractors are not taking advantage of the current advanced applications of IT. Those organisations sampled did not expect to invest in advanced IT applications in the near future, despite recognising the need to identify and exploit the opportunities presented by IT. Consequently, the awareness of construction professionals about the innovative IT applications that are available needs to be improved, perhaps through workshops and professional development programs.

Process re-engineering has been advocated as a recipe for overcoming the industry's problems, as existing processes are radically transformed. Non-value-adding activities which contribute to ineffective communication and information practices would be eliminated. Yet, the principles of process re-engineering have been primarily based on the innovative use of IT. This paper has suggested that to create a new process requires more than the innovative application of IT; it also requires organisational and human innovations.

Process re-engineering that is IT-focused will probably fail, inasmuch as IT is used as the driving force of change without any consideration to other key enablers The mistakes that other industries have made should be learned from, and IT only used as a tool of the change process until the cause of the industry's problems are more fully understood.

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