A Brief Synopsis in the Use of ICT and ICPM in the Construction Industry

Report 2001-008-C-02

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Research Program C:
Delivery and Management of Built Assets

Project 2001-008-C:
Project Team Integration: Communication, Coordination and Decision Support

CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

The Cooperative Research Centre for Construction Innovation (CRCCI) research project 2001-008-C: *'Project Team Integration: Communication, Coordination and Decision Support'*, is supported by a number of Australian industry, government and university based project partners including: Queensland University of Technology (QUT); Commonwealth Scientific Industrial Research Organisation (CSIRO), University of Newcastle; Queensland Department of Public Works (QDPW); and the Queensland Department of Main Roads (QDMR).

Supporting the project's research aims and objectives, and as the first major deliverable for the project, this report provides an overall 'snapshot' of current public and private Architectural, Engineering, and Construction (AEC) industry sector statistics, practices, cultures and research directions towards the implementation and application of ICPM and ICT tools and systems.

EXECUTIVE SUMMARY

Project 2001-008-C (Part B): Project Team Integration: Communication Coordination and Decision Support

CRCCI Research Project 2001-008-C (Part B) focuses on the potential of information and communication technology (ICT) to integrate construction project teams. The project critically evaluates the use of Internet-based Construction Project Management (ICPM), e-tendering, e-archiving of project information, and cultural/relationship barriers/enablers to the adoption of these innovative ICT solutions. This project leverages off previous international and local research in the area and draws together the activities undertaken within both the public and private sectors with a view to establishing a uniform 'best-practice' model that can be adopted by the industry.

International Statistical Indicators – Comparative Use of Computers, WWW and Internet

In the past, older and more expensive technologies did not allow information to be stored in a cost-effective manner or form that clearly replicated a printed copy of the document saved. Today the number of businesses using computers, accessing the Internet and using web sites or home pages continues to grow. This is mainly due to personal computers (PCs), local and wide area networks (LAN / WAN), data storage devices, email, Internet, World Wide Web (WWW) and other ICT tools and systems making it possible for individuals and small businesses to (cost-efficiently) create, process, transmit and store information electronically (Schelberg and Weinstein 1999).

Today's Government departments and agencies now offer a wide range of (current and anticipated) e-Commerce facilities / services that greatly reduce administrative and other costs. Current Government services (via the Internet) include:

- placing procurement processes online;
- allowing private companies to bid for calls to tender;
- selling of publications, surplus supplies, property and licences;
- facilitating citizens to vote;
- submit applications; as well as
- register for services, etc (Ecommerce 2002).

The availability of these products and services are fortunately on the increase, further influencing current and future relationships between public and private sectors through:

- improved efficiencies and reduced costs (both public and private);
- increased transparency;
- decreased inconsistency, loss or misplacement of information, applications and documentation (automated electronic record); and
- less likelihood for corruption (particularly in weak economies) (NOIE 2001; Ecommerce 2002).

From an international perspective, many of the countries selected for benchmarking against Australia have confirmed high levels of adoption and use of ICTs, with increased levels of economic and social activity occurring online. Australians are seen to be major adopters of innovative ICTs (e.g. computers, mobile telephones, etc), and increasingly use the Internet for a wide range of associated day-to-day activities. Yet, there is still significant room for improvement. The majority of countries (including Australia) still have large sections of their

respective populations and industry sectors located 'outside' the 'information economy', caused by either (a) having access to ICTs and the Internet, but not using this resource, or (b) not having the opportunity to use ICTs and the Internet, due to lack of access (NOIE 2002).

Electronic Commerce

The real impact of e-commerce is in delivering productivity and efficiency benefits through a transformation of business processes and forging savings along the value chains of industry sectors. Importantly, e-Commerce is not only seen as a way of cutting costs, but also as transforming business and creating new value chains. The challenges of implementing e-commerce are now better understood and estimates of potential benefits are becoming more realistic, underpinning productive growth in the economy. Needless to say, e-Commerce is more than 'simply putting up a website or implementing a system for electronic procurement', providing industry organisations with the means to 'inject' greater efficiency into tasks, such as data collection and data management, thereby freeing up company resources and requiring less focus on administrative processes and more on strategic activities (APCC 2001).

Current and future ICT and e-Commerce developments and their applicability and uptake within the public and private sectors of the construction industry, is causing virtually every business sector to shift away from traditional, tried and tested methods of communications, effectively revolutionising the way today's companies trade and conduct business. In Australia, some large organisations are well advanced in establishing their own portal sites for private or internal use, such as Project Services (Queensland) with their eProject site (Appendix III), and Bovis Lend Lease with their site ProjectWeb (Appendix IV).

Today there are already in excess of 180 ICPM Web sites or project management "portals" which have been established to service today's Architectural, Engineering, and Construction (AEC) industry market requirements (Orr 2000). The more high-profile semi-public project portals can be viewed in Appendix IV, and include Autodesk's Buzzsaw.com site, Bentley's recently launched viecon.com site, and Cephren's ProjectNet.com site. Companies such as BidCom, BricsNet, BuildPoint, CADX, Cubus, Meridian, and PrimaVera are also found to have a strong presence through sites such as Buildon Technology's projectCentre site; Meridian's ProjectTalk.com site; IronSpire's JobSite™ system; Constructware's Constructw@re system; and Framework Technologies ActiveProject system (Crawford and Wilson 2000).

Although certain sectors and stakeholder groups within the construction industry are identified as embracing various ICT and ICPM tools and systems, the industry's overall e-uptake is unfortunately very much reserved, especially when compared to other engineering sectors (e.g. automotive and aerospace industry). There are justifiably many reasons for this restricted uptake, two of the more 'prominent' being (a) the fragmented nature of the industry, and (b) the one-off nature of its projects (Anumba and Ruikar 2002).

Motivated by the above, one of this project's research activities / deliverables (Section 1.2) include a detailed investigation in determining the local and international government and industry sector's e-Commerce 'current state-of-play', including e-Tender and e-Archive activities. These findings are presented in a report to be release later this year.

Organisational Culture

Because culture has its own history of success, which reinforces and strengthens the organisation's way of doing things, the global competitive business environment has made

the culture of an organisation a critical aspect of its success (Sadri and Lees 2001). Older and more successful organisations tend to have stronger cultures, natures, and identity, by way of 'communities' of people that have a mission and machine-like characteristic that serve the needs of the immediate and wider organisational community (Schneider 2000; Meudell and Gadd 1994).

Furthermore, organisations that have the supposed 'optimum' ICT implementation strategy may (in some cases) find it worthless. That is to say that if the organisation's culture is not properly aligned with, and supportive of, the implementation strategy, the strategy will either stall or fail (Schneider 2000). Organisations, as members of the largest productive industry of any developed country, need to find the ability to trust each other again, and break away from the 'undertaker' or 'caretaker' approach to ICT innovation, and become more 'risk takers'. Unfortunately, this transformation of personalities is not easy, hindered by the industry's exceptionally fragile level of 'trust' (Section 5.3.3), which is currently replaced by fear of litigation. (Michel 1998).

Therefore, one of the last available 'mechanisms' left for organisations to improve their competitive position within the construction industry is by considering people (human resources) along with technology. By employing a dedicated, highly skilled, flexible, co-ordinated, committed and productive workforce, coupled with a leaner, flatter and more responsive organisation will ensure a more effective and successful implementation of innovative ICTs (Morley and Heraty 1995).

ICT and Change

Construction organisations are faced with many new challenges, including the need to change current work practices; become more client orientated; become more competitive; and become more productive (Love 1996). These challenges are attributable to factors that effect the working environment, including globalisation of the economy; greater performance expectations from the clients; increased competition between local contractors; continued restructuring of work practices and industrial relations.

The industry has to realise that investing in ICT is no longer primarily buying a piece of hardware or software. It is now more of a potential long term investment in the process of change itself (Cleveland 1999; Buch and Wetzel 2001). Unfortunately, the nature of the industry's constructed products, its organisations and processes, limit technological change within the industry (Gann 1997).

Therefore, achieving a balance between the industry's need and organisational cultures is a 'key construct' in understanding and managing the behaviour of people within the boundaries of an organisation and in implementing a technical (ICT) driven change (Cabrera et al. 2001). Successful ICT implementation requires careful consideration to the 'human touch' by determining new / improved ways of innovating the user, not only the technology (Gore 1999; Ahmad 2000; Claver et al. 2001). This will inevitably result in a firm or project experiencing previously unknown increased levels of professionalism and benefits, including:

- a better standard of work;
- more cost effective projects;
- fewer delays and expensive mistakes;
- fewer accidents and less ill health;
- reduced staff turnover;
- earlier completion dates;
- an advantage over competition; and
- increased repeat business (Rethinking Construction 2000).

ICT Implementation Advantages and Drivers

Generally, ICT applications are 'confined' to each sector of the industry, and any benefits experienced restricted to that sector. These cross-sector ICT benefits are threefold:

- First, ICT is used to **improve the efficiency**, speed and quality of communication across sectors, thereby reducing cycle times and increasing quality for the whole supply chain.
- Second, ICT can be used to facilitate the creation of a **transformed supply chain** by taking a different approach to cross-sector relationships. By encouraging greater concurrency between tasks conducted by firms in different sectors through increased sharing of information can ultimately achieve substantial savings in time and money for the client.
- Lastly, ICT can **increase the total value** of the project to the client (operator) through improved sharing of information and knowledge between, for example, the design team, contractor and suppliers, encourages collaboration in identifying new and improved solutions to unforeseen problems on a project (Fujitsu Centre 1998).

Factors associated with successful adoption and implementation of ICT includes:

- taking an incremental approach to ICT implementation;
- ensuring new ICT systems have business benefits;
- changing / re-engineering the organisation to take advantage of the technology;
- use of individual projects to fund incremental adoption and as an opportunity to learn to use the new technology;
- training and development of staff to be able to use the technology successfully; and
- top-level management 'buy-in' (Fujitsu Centre 1998).

ICT Implementation Barriers and Challenges

Implementation is the '*challenge that comes at the end of all new (and old) methods for improving organisations*', including: architecture development, change management, total quality management and new ICT systems (Revenaugh 1994). The construction industry is rapidly becoming a 'multidisciplinary, multinational and multibillion-dollar economy', involving large number of participants working together at dispersed locations whilst implementing various ICT technologies, becoming an information intensive industry (Rezgui et al. 1998).

It is predicted that higher quality (e.g. online) training and courseware will become standard methods of training. As a result, meeting the ever-broadening needs of industry learners and organisations and altering the industry's learning experience in future decades (Kilby 2001). With this in mind, ICT implementation teams and trainers may want to consider the following 'action points' to help accommodate this ICT adopting and learning industry:

- firstly, attempt to understand the organisation's culture and attitudes to training;
- recognise all levels of the organisation's culture in order to consider how positive attitudes can be fostered at all of these;
- determine measurable goals for changing attitudes to training in the organisation in relation to time;
- utilise (amongst other things) Table 5-1 to analyse the extent of the problem, the task to be undertaken, and how to bring about change;
- adopt a proactive approach to the advancement of organisational-level training and evaluation by 'promoting' this to senior management and by forging links with line managers and other key players in order to effect new organisational 'beliefs';
- choose a suitable change strategy or strategies to promote these new organisational beliefs;
- involve a wide range of organisational participants in the implementation stage of the attempt to change attitudes; and lastly
- actively evaluate the results of this 'hands-on' approach (Lewis and Thornhill 1994).

Future Industry Trends and Recommendations

Due to the nature of the industry involving large numbers of geographically dispersed organisations and individuals, project communication activities are inevitably complex. Ongoing Research and Development (R and D) efforts in determining ways to improve traditional (paper-based) methods of communicating, through the implementation and application of standard off the shelf ICT tools and systems within the construction industry, accentuates increased recognition of the potential opportunities and benefits these innovative technologies have to offer (Anumba and Ruikar 2002).

Research shows there is also a 'perceived fear' of 'exploitation' of technology-led innovations within the industry, and that industry practitioners are yet to be convinced of supportive terms and conditions of contract do not lead to exploitation. In an attempt to lesson and ultimately remove this fear of exploitation, the industry is to determine ways to:

- Create a common understanding that would enable the construction industry to take positive action.
- Provide appropriate and easily accessible information on risk evaluation and implementation.
- Provide both cultural and contractual changes to remove the constant fear of liability and the concern to assign blame to individuals and organisations - creating an environment that is receptive to ideas, challenges and opportunities.
- Investigate unsuccessful projects to provide lessons for the future.
- Lessen constraints imposed by regulations, codes and standards that tend to oppose novel solutions (CRISP 2000).

When it comes to researching and developing innovative technologies, the construction industry is said to be lagging when compared to other industries (Michel 1998). Yet, the level of ICT adoption by the Australian construction industry appears to be neither more nor less advanced than that of our international competitors. Still, current R and D efforts need to be increased in order to manage ongoing industry implications and inevitability of ICT driven change (including its effect on organisational cultures) (Black and Edwards 2000).

Finally, if Australian organisations continue to explore the competitive 'dynamics' of the construction industry, without realising the current and future, trends and benefits of adopting innovative ICT solutions, it will limit their opportunity to internationalise (expand into overseas markets) and allow the continuation of international firms successfully entering local markets.

Further Reading

As illustrated throughout this report, there are numerous examples of ICT and ICPM implementations as well as R and D activities within the Australian and international construction industry. Appendix V presents an additional six research studies pertaining to international ICT and ICPM R and D activities within the industry.

1 PROJECT 2001-008-C (Part B): PROJECT TEAM INTEGRATION: COMMUNICATION COORDINATION AND DECISION SUPPORT

1.1 Research Background

Construction is one of the most important industries in any developed country, facing a period of rapid and unparalleled change in the next 20 years (Industry Science Resources 1999). The Australian construction industry for instance, is valued at over $30 billion per annum (through the end products it creates), and therefore has the potential to influence the country's GDP more than any other service industry (Love et al. 1996). Yet, the industry is said to be at a critical point in its history, with many 'divides' being created, moving it in new directions (Russell. 2000):

- from paper to electronic media;
- from local to global commerce;
- from a management to a leadership focus; and
- from a reactive to a proactive state.

There also exists within the Australian Architectural, Engineering and Construction (AEC) industries a considerable lack of knowledge about information and communication technology (ICT) systems and other available innovative technologies, which may prove beneficial in the procurement, delivery and life of projects (Kajewski and Weippert 2000; NSW Department of Public Works and Services 1998). Consequently, there is an urgent and vital need to address those key issues that will most significantly influence the construction industry and the way in which it contributes to our society and the economy as a whole in the future.

The success of innovative ICT developments, in terms of industry uptake and usage, can be improved if the conditions of innovation diffusion within project organisations, parent organisations, and the broader industry are understood and brought into play. This includes:

- matching technological innovation with the perceived needs and preparedness for change on the part of the AEC industry and its people, and
- transforming current organisational cultures - where information (seen as a source of power, influence, and importance), is available on a need-to-know basis - into more 'open cultures' - where an atmosphere of shared knowledge, experience, mutual trust, and respect occurs within and between organisations (whilst maintaining some degree of control) (Baines 1998).

Once these 'divides' are crossed, 'new realities' will be realised in certain 'trends' of the construction industry. These 'trends' will reshape the industry as we know it, further signifying AEC industry members work closer together if they are to become and / or remain leaders in a competitive, global market place. AEC industry trends include:

- **Fully integrated and automated project processes**: a seamless delivery process - with no disconnects between planning, design, procurement, construction, and operation and maintenance. Empowered, cross-discipline teams will incorporate expertise from designers, contractors, specialty contractors, vendors, suppliers, and operations and maintenance staff. The industry has passed through the 'Industrial Revolution' and the 'Agricultural Revolution', and is now in the 'Information Revolution'. Today, virtual design teams, computer- aided design / computer-aided construction; virtual reality; animation; the World Wide Web (WWW); e-mail; and electronic commerce and data interchange are commonly understood and used.
- **Owner requirements modifying the roles of the designer and the contractor**: Owners expect safely constructed products, which are built quickly and economically to a

specified quality and are operated and maintained efficiently. The roles of the owner, the engineer, and the contractor are changing in response to such project delivery systems as design/build, design/build/warrant, design/build/operate/maintain, and finance/design/build/operate. 'One-kind-fits-all' delivery systems no longer work in the fluid global marketplace, and performance- based specifications will continue in the next millennium.

- **Globalisation of the industry**: In the late 1950s, contract awards were made on a competitive bid basis. In the 1970s and 1980s, however, there was a significant shift to international markets because:
  - domestic economics (oil and real estate) reduced construction demand;
  - owners began outsourcing rather than performing design and construction themselves;
  - design and construction technologies were transferred to Third World countries; and
  - owners moved their manufacturing to expanding markets.

  In the 1990s many mergers, acquisitions, and ownership changes that publicly traded companies would never have contemplated 25 years ago took place. The is said to be heading toward the globalisation of design engineering (round-the-clock engineering), materials, equipment, and labour - with importing from the Third World.
- **Increased role of suppliers**: Business results accrue through a supply chain. To better integrate, plan, and schedule, as well as achieve maximum quality and ability to evaluate economic options, all parties need to be engaged as early as possible in project planning when essential decisions need to be made.
- **Reduced project cycle time**: '*time is money'* - Industry organisations (large and small) must understand the economics of capital investment and be innovative in organising themselves to meet the increasingly stringent demands of the owner.
- **Changes in skilled workforce**: Attracting, training, and retaining a motivated, skilled workforce are essential to successfully meeting the demands on the construction industry. An industry wide marketing plan is suggested to recruit the men and women who actually build our projects (Russell 2000).

1.2 Research Aims and Objectives

The main objective of the 2001-008-C (Part B) research undertaking briefly aims to:

- Demonstrate leadership in facilitating the use of online technologies for the design, management and construction of building and civil construction projects.
- Identify appropriate ICT solutions that will improve resource management, support and integrate total project life cycle considerations, increase efficiencies on projects, ultimately reduce overall cost and improve project outcomes to project participants in the public and private sectors.
- Test, field trial and/or evaluate ICT systems allowing the above issues to be addressed, evaluated and studied in depth.
- Examine the cultural and ICT implementation barriers and needs that challenge organisations and project teams - by focusing on identifying and assessing human and cultural factors, limitations, barriers, and drivers as they arise from the nature of the AEC industry.
- Establish case study projects that will foster the expansion of ICTs in the building and civil construction sectors, thus stimulating the use of such technologies in public and private building and infrastructure projects – potentially resulting in increased ICT knowledge, awareness and skills of companies in both the public and private sector.
- Demonstrate the benefits and efficiencies obtained through Internet-based Construction Project Management (ICPM) solutions - thereby stimulating improvements and encouraging the wider adoption of such processes in the AEC industries - potentially delivering projects in a timelier and cost efficient manner.
- Demonstrate the potential for the use of hand-held technologies/applications - by examining the existing and emerging technologies not yet embraced by the AEC industries.

- Determine the state-of-play concerning e-Tendering and e-Archiving and will ascertain the barriers and enablers from both a technological and legislative perspective.

To help realise the above project aims and objectives, the project schedule in APPENDIX I provides a breakdown of projected research activities, deliverables, milestones, and allocated timeframes.

1.3 Report Aims and Objectives

Supporting the above research aims and objectives, and as the first major deliverable for the 2001-008-C (Part B) research project (Figure 12-1), this report includes:

- an overall 'snapshot' of current public and private AEC industry sector statistics, practices, and research directions in the implementation and application of ICPM and ICT tools and systems;
- examining the industry's need for technological innovation and change;
- identifying various e-Business and e-Commerce categories, applicability and uptake within the AEC industry;
- an initial investigation into the cultural/relationship barriers/enablers to the adoption of these innovative communication technologies; and
- highlights future industry trends and recommendations.

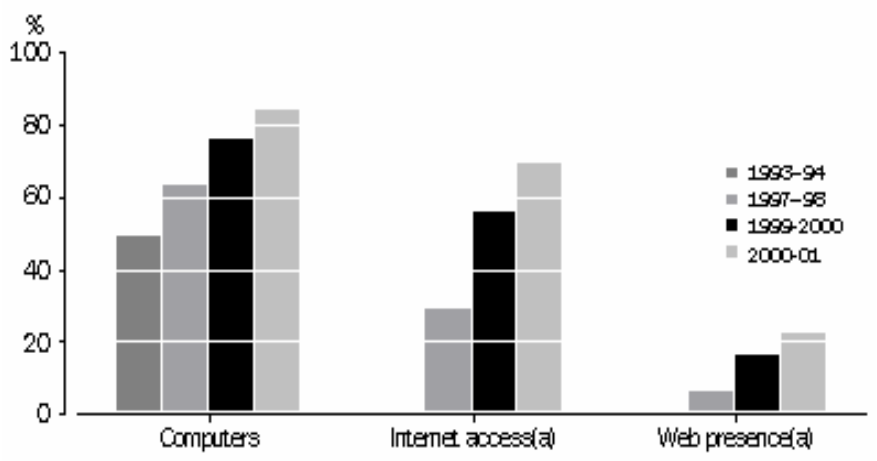
2 INTERNATIONAL STATISTICAL INDICATORS – COMPARATIVE USE OF COMPUTERS, WWW and INTERNET

The following sections provide local and international statistical information (1998 - 2002) pertaining to the use of innovative ICT (e.g. computers, etc) and internet (e.g. Web presence, etc) solutions for industry, government, and business sectors.

2.1 Australian Businesses

Computer use has shown steady growth, rising from 49% of Australian businesses (1993-94) to 84% of businesses at the end of June 2001(Figure 2-1). In contrast, the proportion of businesses with a Web presence has grown rapidly i.e.: rising from 6% (1997-98) to 16% (1999-2000) and 22% (2000-01). The proportion of businesses with Internet access has also risen rapidly, from 29% (1997-98) to 56% (1999-2000) and 69% (2000-01) (ABS 2002).

Figure 2-1: Australian Businesses Using IT



Extract from (ABS 2002)

Note:
(a) – Data not collected for 1993-94

Sections following provide a breakdown of the above Australian businesses and their current level of ICT uptake (Figure 2-1) in relation to their size, industry sector, and location (region and state).

2.1.1 By Business Size

A strong relationship exists between the employment size of a business and the likelihood that the business is using ICT. As employment size increases, so does the proportion of Australian businesses making use of ICT – e.g. at end June 2001, majority of large businesses (those employing 100 or more persons) used computers (100%) or had access to the Internet (99%), while 81% had a Web presence. In contrast, small businesses (those

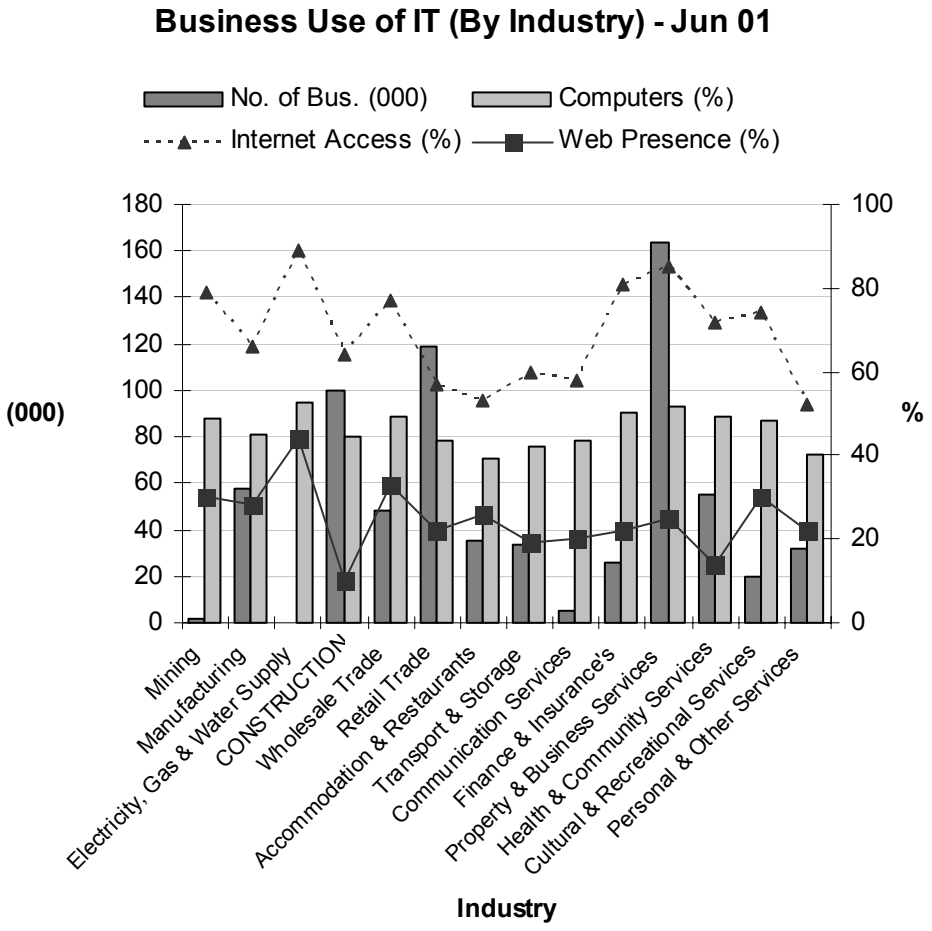
employing fewer than 5 persons) had a lower level of IT adoption; 79% used computers, 64% had access to the Internet and only 14% had a Web presence (ABS 2002).

2.1.2 By Industry

At the end of June 2001, the proportion of Australian businesses using information technologies varied considerably across industries (Figure 2-2) (ABS 2002):

- The proportion of businesses using (a)computers or (b)with access to the Internet was recorded lowest in the:
  - 'Accommodation, cafes and restaurants' industry: (a)71% and (b)53%; and in the
  - 'Personal and other services' industry: (a) 72% and (b) 52%.
- Computer and Internet use was recorded highest in the 'Electricity, gas and water industry' (95% and 89% respectively).
- The highest proportion of businesses with a Web presence was also verified in the 'Electricity, gas and water industry' (44%), while the lowest proportion was in the *Construction industry* (10%).

Figure 2-2: Business Use of IT (By Industry) – June 2001

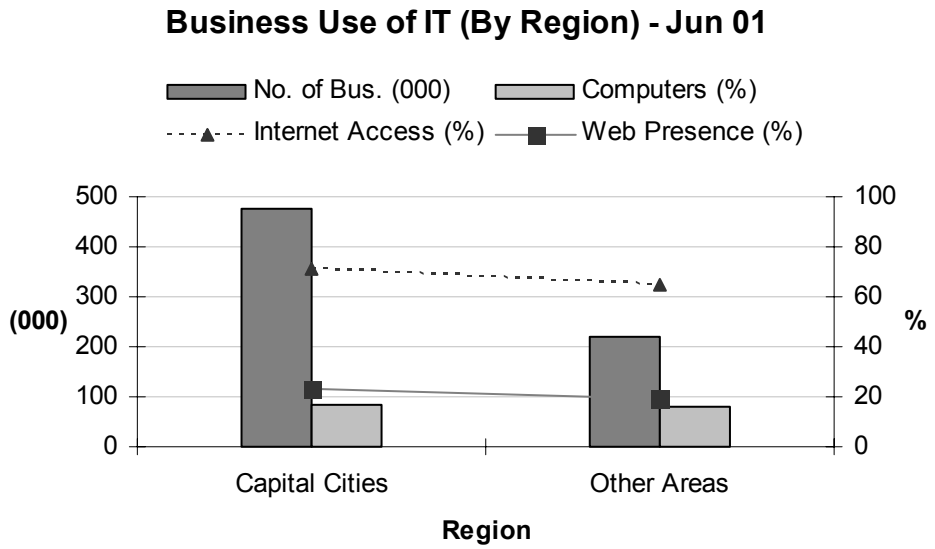


2.1.3 By Region

There were only minor regional differences recorded in the use of IT at the end of June 2001. As shown in Figure 2-3, minor differences were recorded in the proportion of businesses with Internet access (71% in capital cities and 65% in other areas) and lessor differences in the proportion of businesses using computers (84% and 82% respectively). Even the proportion

of businesses with a Web presence showed only a modest difference between businesses in capital cities (23%) and those in other areas (19%) (ABS 2002).

Figure 2-3: Business Use of IT (By Region) – June 2001



2.1.4 By State

At the end of June 2001, the proportion of Australian businesses using information technologies and the Internet (at a state level) varied considerably (Figure 2-4, Figure 2-5 and Figure 2-6). A summary of these results can be found in APPENDIX II (ABS 2002):

Figure 2-4: Business Use of IT (By State) – June 2001

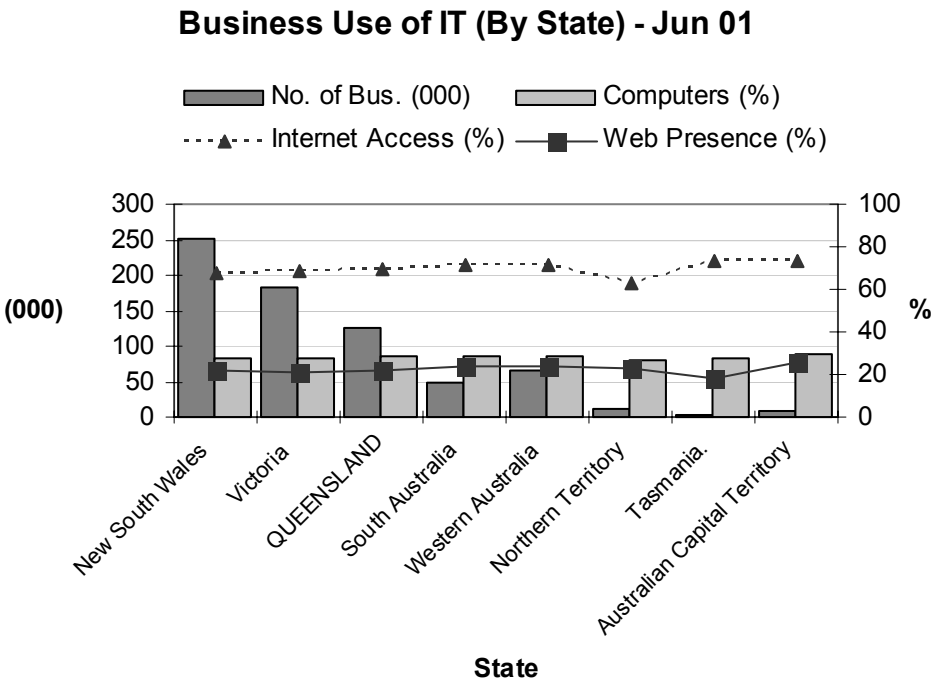
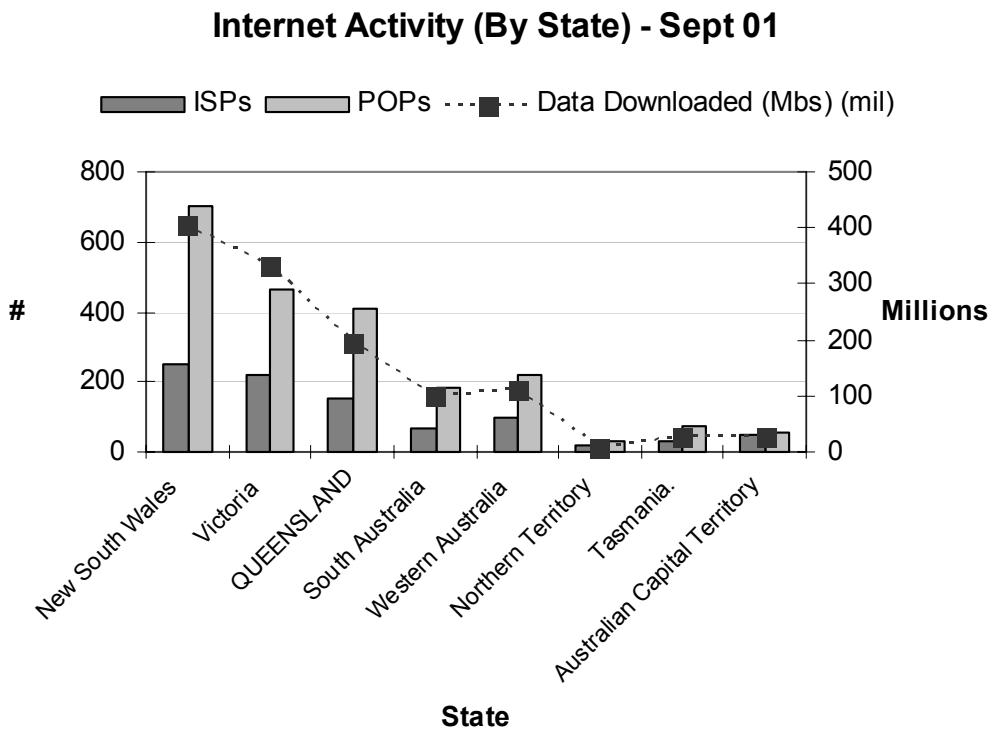
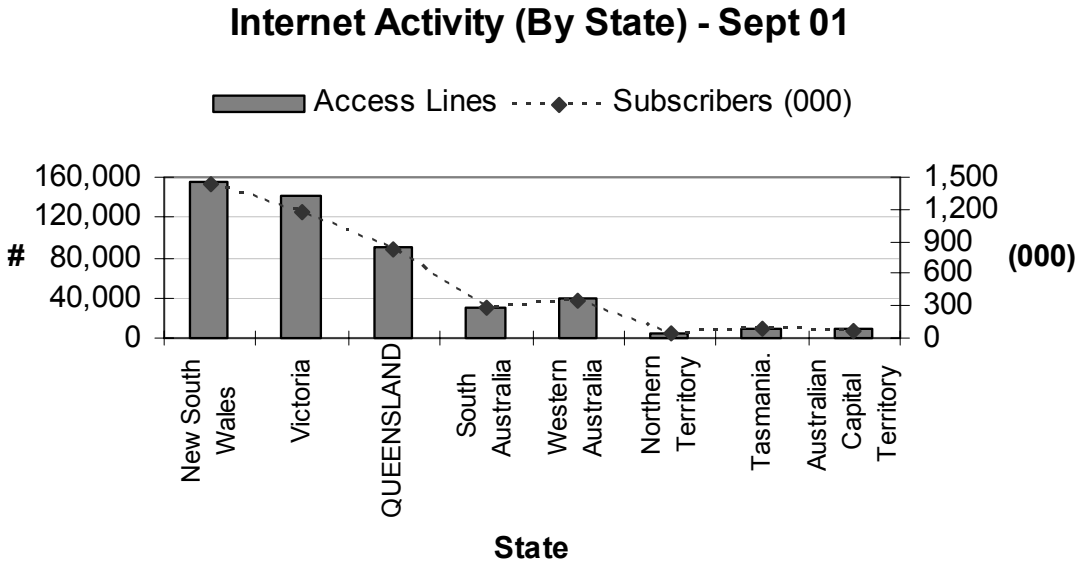


Figure 2-5: Internet Activity (By State) A – September 2001



Note:
POP is a server in a geographical location where a subscriber can access (connect to) an internet service provider (ISP) via access lines (ABS 2002).

Figure 2-6: Internet Activity (By State) B – September 2001

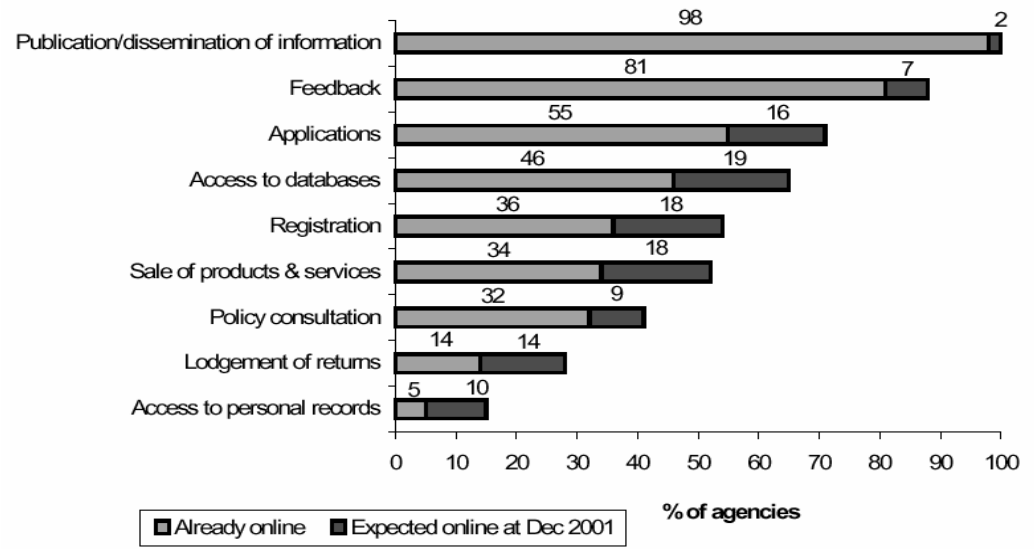


2.2 Australian Government (1998-2002)

2.2.1 ICT and Internet

The Australian Commonwealth Government has announced a 'whole-of-government portals framework' to provide a customer-focused coordinated approach to the Commonwealth's online presence. The framework intends to facilitate 'cross-agency services' and capture opportunities that exist in the online environment – i.e.: to tie together information and services (typically delivered separately), providing efficiency benefits for both users and government. The frameworks 'intentions' included that the first nine portals were to be online by August 2001, with a further nine established by June 2002. The nine portals (based on customer groupings and topics) were to be business; regional; youth; families; education; agriculture; culture and recreation; science and industry; and employment). All government agencies were also expected to publish / disseminate information online, and 88% were to have 'feedback capacity' by the end of 2001. Furthermore, six of the nine service types shown in Figure 2-7 were to be available on the majority of agencies' web sites by the end of 2001 (NOIE 2001).

Figure 2-7: Percentage (%) and Type of Australian Government Services (2001)



Extract from (NOIE 2001)

High levels of PC use for all levels of government departments and agencies recorded by end June 1998 were (Figure 2-8):

- 100% Federal, State/Territory, and local; and
- 94% other (ABS 1999).

Furthermore, Federal departments and agencies had 100% access to the Internet Figure 2-9, with State/Territory (85%), local (77%), and other government agencies (60%) closely following. Interestingly, of the 1,798 government agencies, 73% recorded having access to the Internet, and only 898 (37%) had a web site or home page:

- 89% Federal;
- 61% State / Territory;
- 28% local government; and
- 21% other government (ABS 1999).

Figure 2-8: Government Use of PCs – June 1998

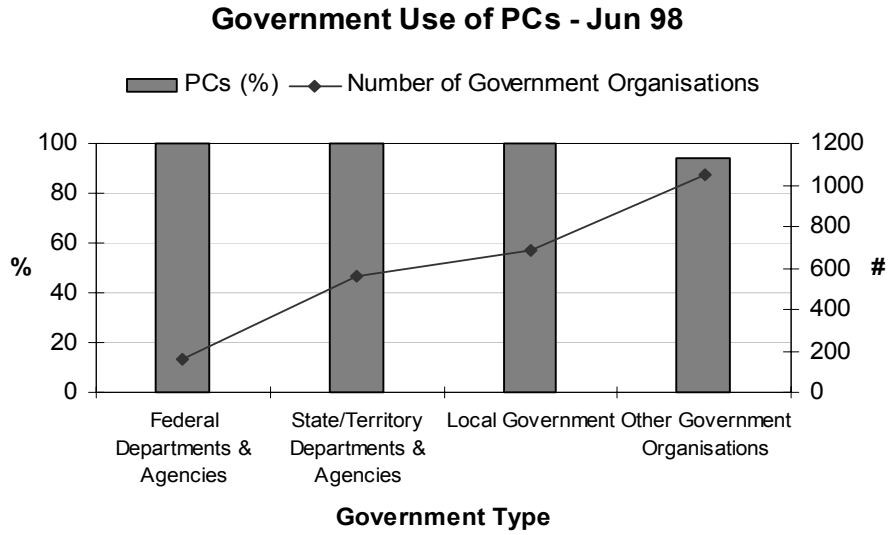
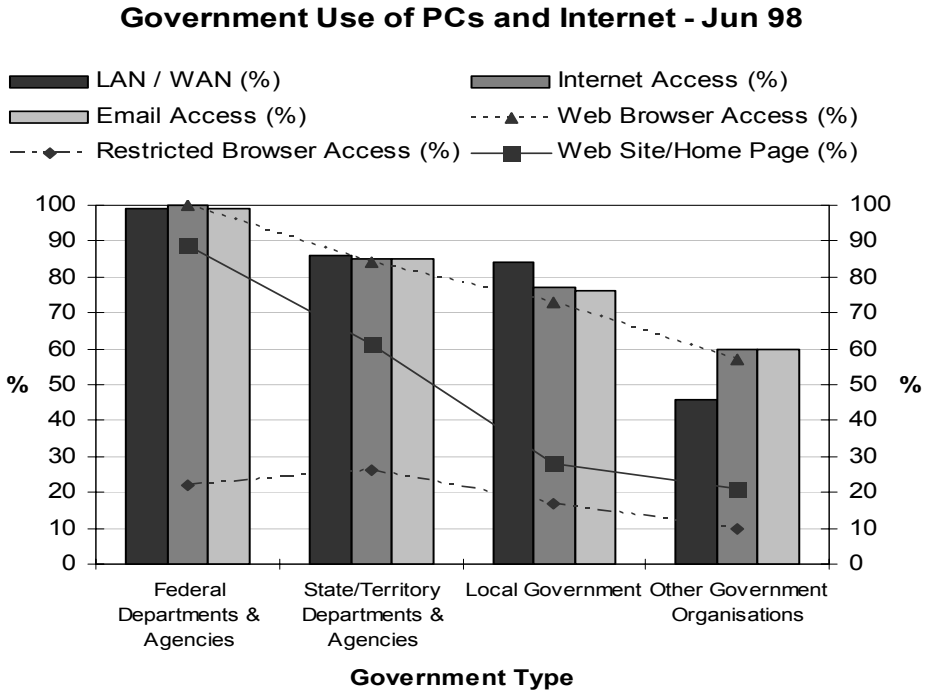


Figure 2-9: Government Use of PCs and the Internet – June 1998



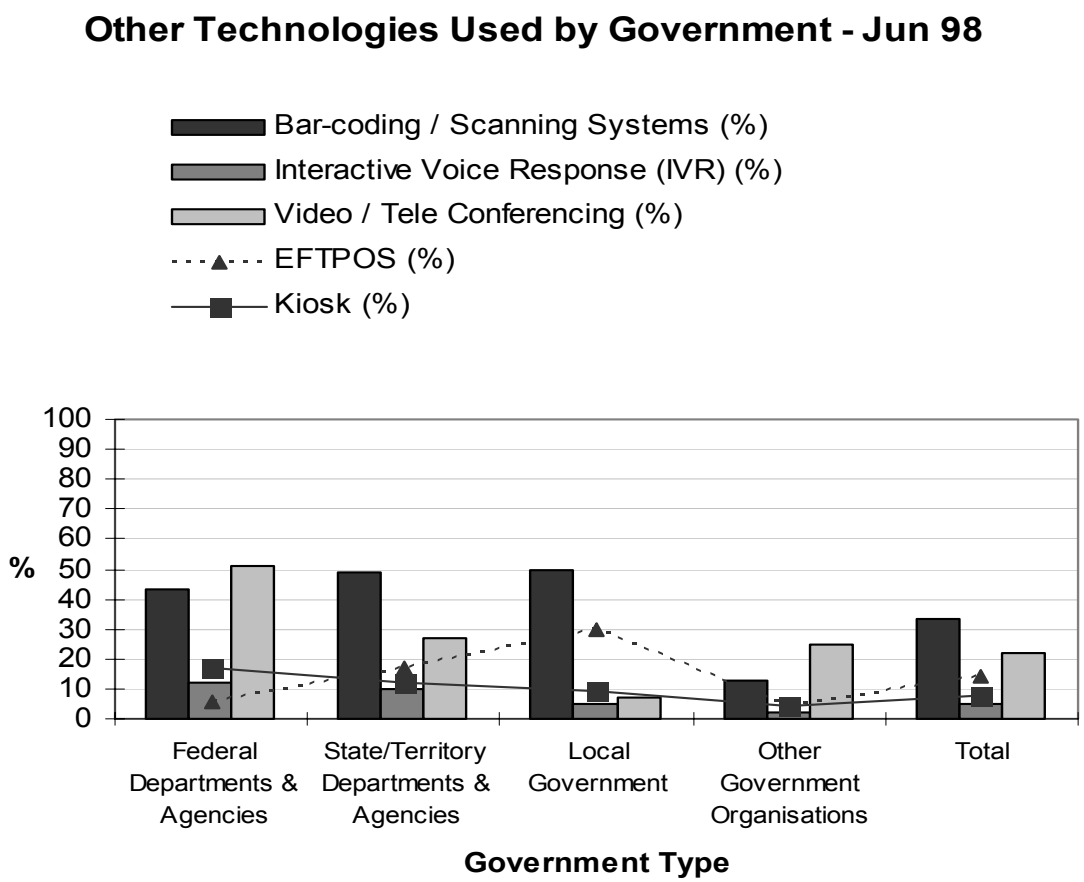
Note:
Government organisation 'types' referred to in Figure 2-8 and Figure 2-9 are:

- ***Federal departments and agencies:*** *defined as Australian Government Departments, Australian Government Legislature, Courts, Australian Government Industry and Marketing Boards and Australian Government Statutory Authorities.*
- ***State/Territory departments and agencies:*** *defined as State/Territory Government Departments, State/Territory Government Legislature, Courts, etc, State/Territory Government Industry and Marketing Boards and State/Territory Government Statutory Authorities including essential services agencies.*
- ***Local government:*** *defined as Local Government Authorities, and Aboriginal and Torres Strait Islander Community Councils.*
- ***Other government organisations:*** *defined as Federal, State/Territory and local government organisations not included elsewhere, including government owned companies (ABS 1999).*

2.2.2 Other Innovative Technologies (1998)

At the end of June 1998, 33% of government organisations used bar-coding / scanning systems; 22% used video conferencing / teleconferencing; 8% offered kiosk facilities; 5% used interactive voice response (IVR); and 14% offered EFTPOS facilities (Figure 2-10). EFTPOS usage was highest in local government (30%); compared to only 6% use in Federal, and 17% in State / Territory departments and agencies. Interestingly, the usage for most of these technologies increased with employment size (Table 2-1).

Figure 2-10: Other Technologies Use by Government – June 1998



Note:

- ***Bar-coding/scanning systems:*** *Commonly used for tracking inventory and pricing goods e.g. a business scans the product barcode to read the price of the product into the cash register.*
- ***Interactive Voice Response (IVR):*** *An automated process of dealing with clients, e.g. recorded phone messages that direct the caller to dial a specific number/s to enable a specific activity to occur.*
- ***Video conferencing/teleconferencing:*** *Refers to a method of 'live' two-way video and audio communication.*
- ***Electronic Funds Transfer Point of Sale (EFTPOS):*** *a method of purchasing/making payments (i.e. a method for performing a financial transaction).*
- ***Kiosk:*** *Includes all public access devices: databases of information, which can be accessed by the public to obtain general and specific information, to make credit card payments, lodge government forms, etc.*

Table 2-1: Government Employment v Technology Used (1998)

GOVERNMENT EMPLOYMENT V TECHNOLOGY USED (1998)	
GOVERNMENT ORGANISATION	**RESULT**
With 1–99 employees	• 15% had bar-coding/scanning systems; • 2% had IVR; • 19% had video conferencing/teleconferencing; • 6% had EFTPOS; and • 6% had kiosk facilities.
With 1,000 or more employees	• 84% had bar-coding/scanning systems; • 28% had IVR; • 61% had video conferencing / teleconferencing; • 24% had EFTPOS; and • 19% had kiosk facilities.

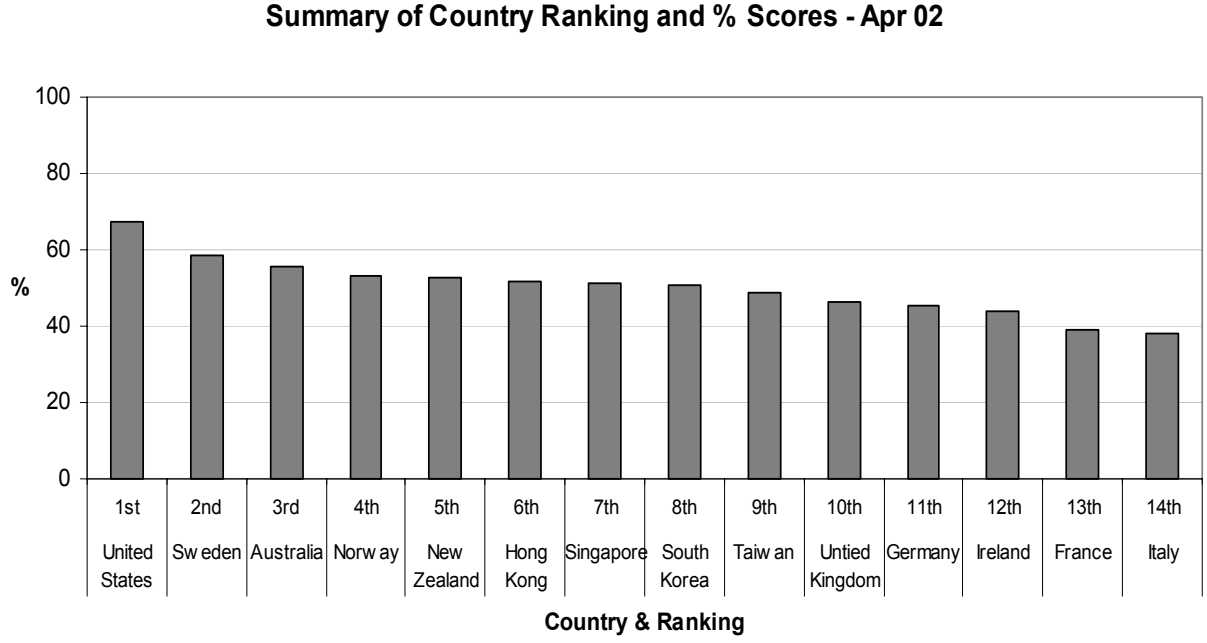
2.3 International Comparison (2000-2002)

2.3.1 Australia v 14 Key Countries (2002)

The 'Current State of Play Report' (NOIE 2002) measured Australia's participation in the international 'information economy', by focusing on key aspects of community and business use of Internet and ICT. Whilst Figure 2-11 provides a summary of these findings, APPENDIX III (Table 12-2) provide detailed results and rankings for the fourteen key countries investigated (across twenty-three statistical indicators), including:

- individual scores for each indicator;
- total score calculated across all indicators;
- average score, which is used to produce the final country ranking, calculated by taking the total number of points each country received and dividing by the number of indicators for which data is available; and
- final ranking from 1 to 14 (14 being the lowest rank)

Figure 2-11: Summary of Country Ranking and % Scores – April 2002



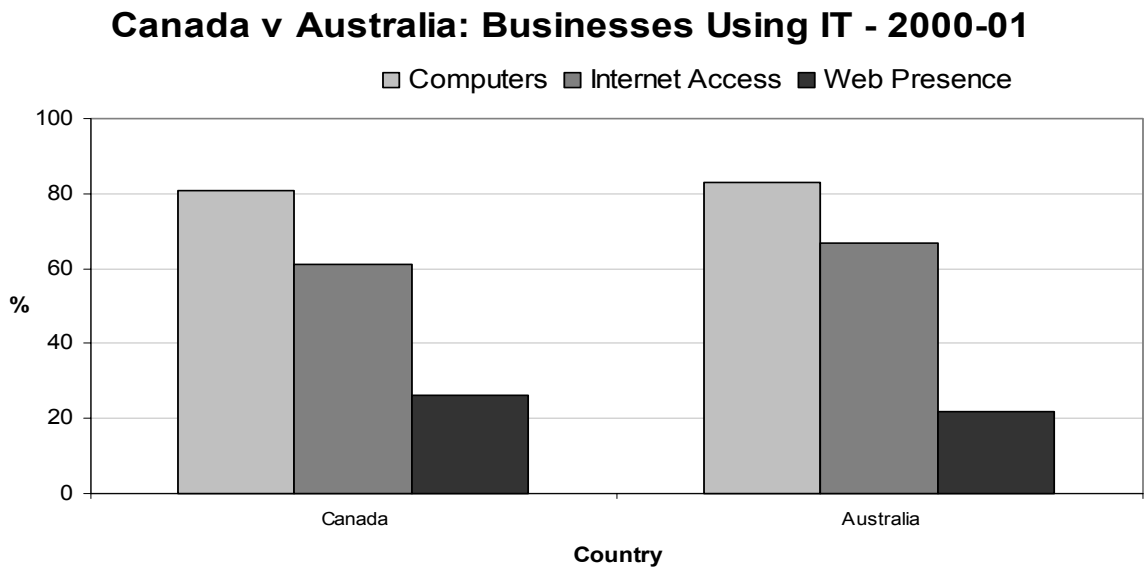
Results indicate that the United States (US) ranked the highest, with consistent performances across the range of Index indicators. The US, Scandinavian countries, Australia, New Zealand and the smaller countries of South East and East Asia are also in a strong position to take advantage of the potential benefits of the emerging global Information Economy. The US (67.3), Sweden (58.4), Australia (55.7) and Norway (53.3) occupy the top four positions in the NOIE Index. Other countries also recording a relatively high Index score include New Zealand (52.8); Hong Kong (51.5); Singapore (51.1); and South Korea (50.5). The remaining two positions in the top ten were taken by Taiwan (48.5) and UK (46.5), followed closely by Germany with 45.4 points and Ireland with 43.8 points, whilst France and Italy occupied the last two positions with significantly lower scores (39.15 and 38 points respectively).

Due to differences in the 'scope' and 'content' of surveys covering these topics, Australian statistics can only be compared with those from a relatively small number of other countries. Therefore the following sections present a summary of these international comparisons, whilst the adjusted 'scope' of the Australian survey (for the UK and Nordic comparisons) can be viewed in APPENDIX III (ABS 2002).

2.3.2 Australia v Canada (1999-2001)

There seems to be little difference between Australia and Canada's uptake of computers, Internet or web sites / home pages (Figure 2-12). This, according to (ABS 2002), may be attributable to the later reference period for the Australian survey (2000 v 2001). Australia is slightly ahead on computer use and Internet access, but trails behind Canada (slightly) with regard to web site use by businesses.

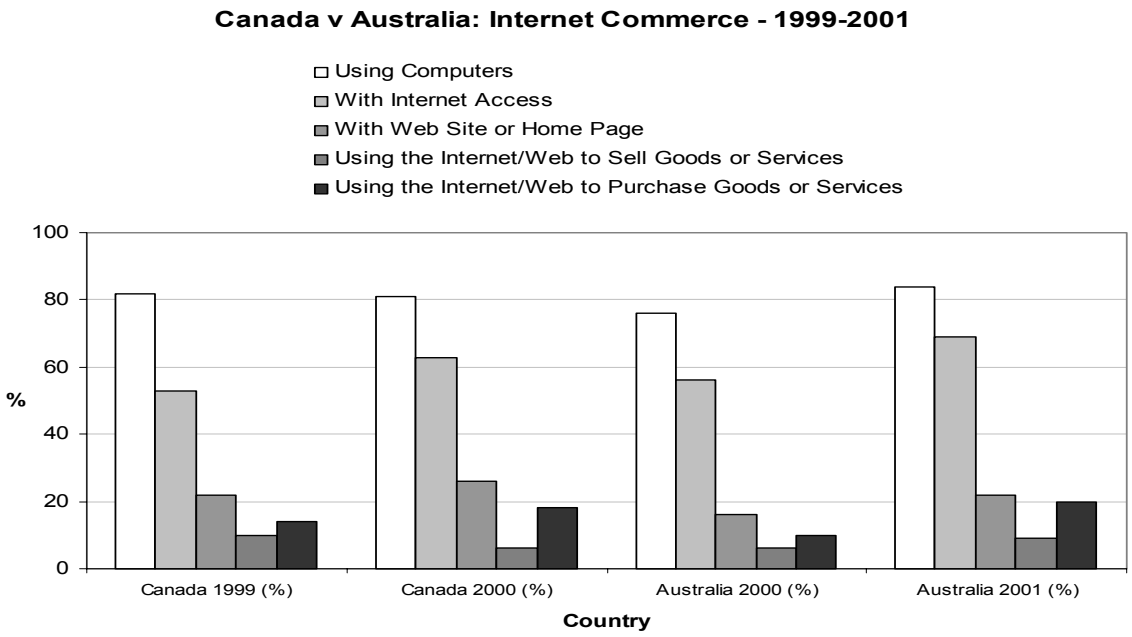
Figure 2-12: Canada v Australia: Businesses Using IT – 2000-01



Note:
Canadian Data is for 2000 and Australian data for 2000-01.

Australian and Canadian comparisons of Internet commerce (1999-2001) indicate that whilst the proportion of businesses using the Internet / Web (to sell goods or services) has increased for Australia, it has decreased for Canada (from 10% to 6%). The concentration of Internet selling into fewer and larger businesses was the cause of this decrease (Figure 2-13). Yet, for both countries, the proportion of businesses using the Internet/Web for purchasing and the value of Internet sales has increased, with Australia leading on both indicators (ABS 2002).

Figure 2-13: Canada v Australia: Internet Commerce – 1999-2001

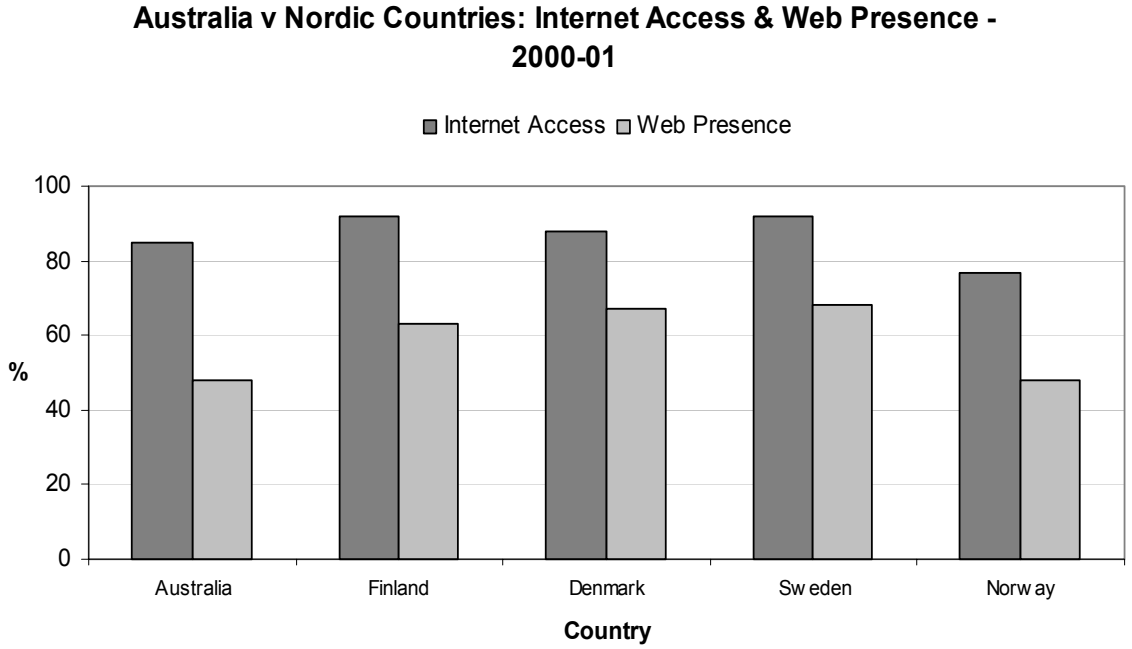


Note:
Canadian data is for 1999-2000 and Australian data for 2000-2001

2.3.3 Australia v Nordic countries (2000-2001)

In terms of business Internet access, Australia compares reasonably well against the Nordic countries, but less for Web presence (Figure 2-14) (ABS 2002):

Figure 2-14: Australia v Nordic Countries: Internet Access and Web Presence - 2000-01



Note:

- *Scope of the Australian survey was adjusted to match the Nordic surveys*
- *Australia Data - 30 June 2001*
- *Nordic Country Data – end 2000*

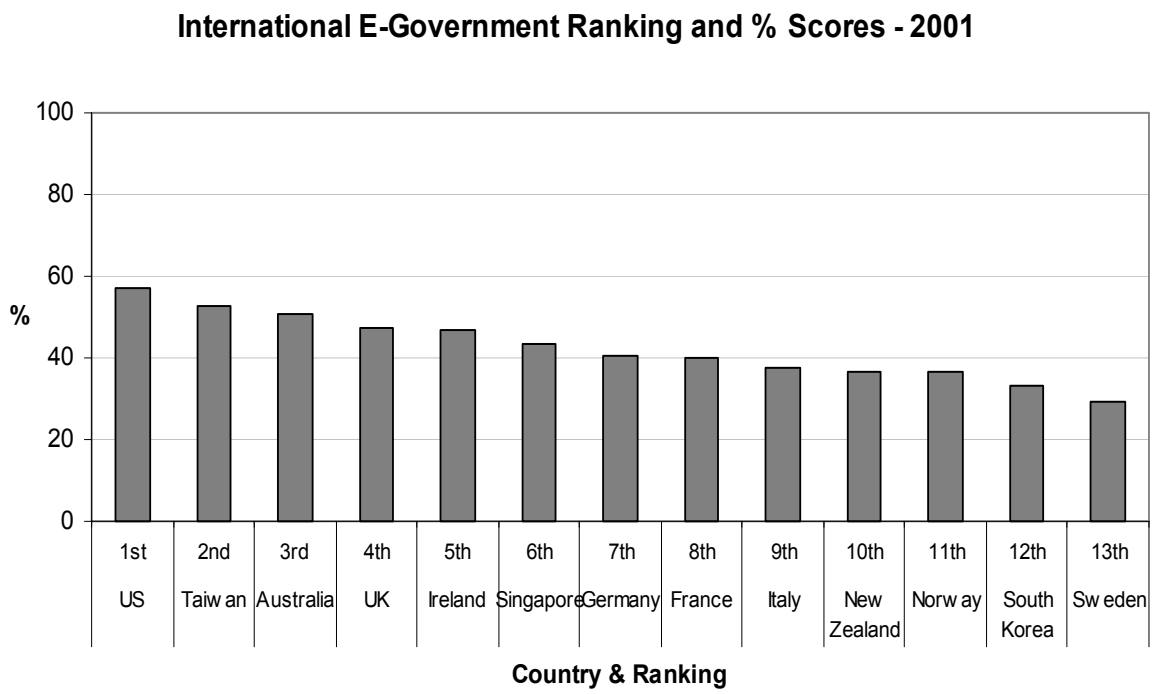
2.3.4 Australia v the United Kingdom (UK) (2000-2001)

When comparing the value of Internet commerce in the UK against Australia, the UK, in respect of Internet sales, is more advanced than Australia. For the UK, the total value of sales made using the Internet for the calendar year 2000 was £13 billion (excluding the Finance Sector), representing 0.94% of all sales made by businesses. The comparable figures for Australia were AUS$6.4 billion and 0.75% respectively (ABS 2002).

2.3.5 E-Government Rankings (2001)

The results of the 'E-Government Rankings' survey produced by the 'World Markets Research Centre', show Australia comparing reasonable well (Figure 2-15). Australia ranked 3rd (behind the US and Taiwan) for its proportion of government web sites. Rankings were based on assessment criteria and scope of information provided on agency web sites - i.e.: clarity of the site, privacy and security policy, etc. In Australia, 50.7% of all the Federal Government agency web sites examined conformed to all assessment criteria - compared to 57.2% US sites (1st) and 52.5% Taiwan sites (2nd) (NOIE 2002).

Figure 2-15: International E-Government Rankings and % Scores - 2001



Note:
Data for Hong Kong for this indicator was not available.

2.4 Summary

In the past, older and more expensive technologies did not allow information to be stored in a cost-effective manner or form that clearly replicated a printed copy of the document saved. Today the number of businesses using computers, accessing the Internet and using web sites or home pages continues to grow. This is mainly due to personal computers (PCs), local and wide area networks (LAN / WAN), data storage devices, email, Internet, World Wide Web (WWW) and other ICT tools and systems making it possible for individuals and

small businesses to (cost-efficiently) create, process, transmit and store information electronically (Schelberg and Weinstein 1999).

Today's Government departments and agencies now offer a wide range of (current and anticipated) e-Commerce facilities / services that greatly reduce administrative and other costs. Current Government services (via the Internet) include:

- placing procurement processes online;
- allowing private companies to bid for calls to tender;
- selling of publications, surplus supplies, property and licences;
- facilitating citizens to vote;
- submit applications; as well as
- register for services, etc (Ecommerce 2002).

The availability of these products and services are fortunately on the increase, further influencing current and future relationships between public and private sectors through:

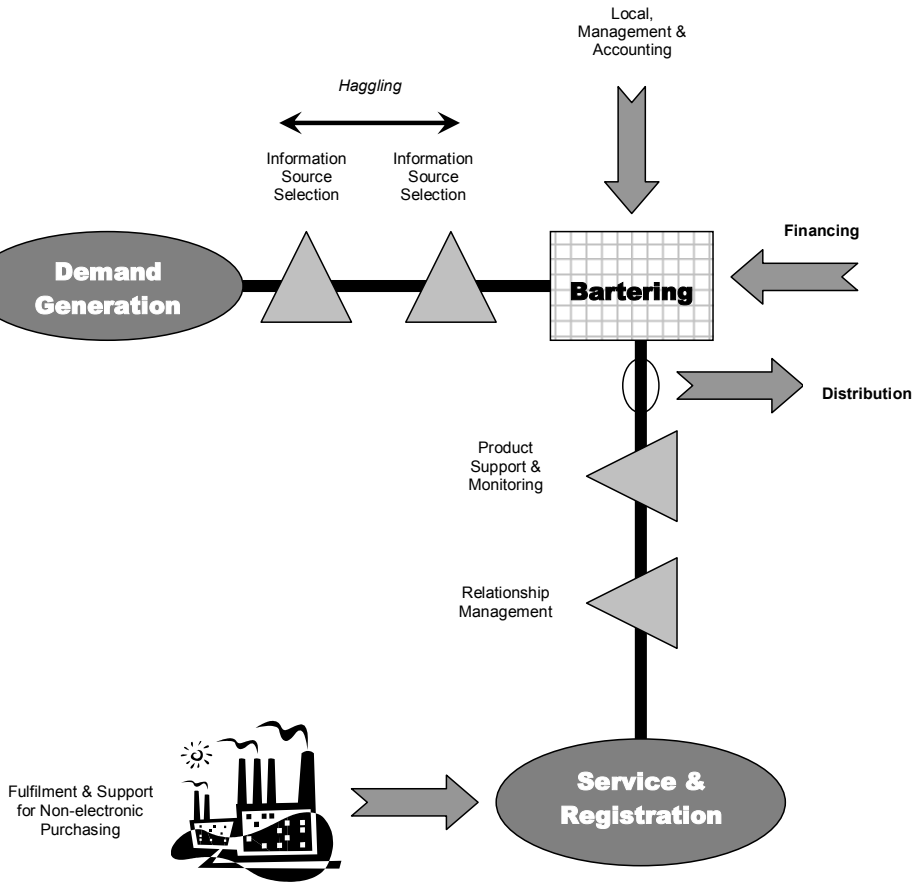
- improved efficiencies and reduced costs (both public and private);
- increased transparency;
- decreased inconsistency, loss or misplacement of information, applications and documentation (automated electronic record); and
- less likelihood for corruption (particularly in weak economies) (NOIE 2001; Ecommerce 2002).

From an international perspective, many of the countries selected for benchmarking against Australia have confirmed high levels of adoption and use of ICTs, with increased levels of economic and social activity occurring online. Australians are seen to be major adopters of innovative ICTs (e.g. computers, mobile telephones, etc), and increasingly use the Internet for a wide range of associated day-to-day activities. Yet, there is still significant room for improvement. The majority of countries (including Australia) still have large sections of their respective populations and industry sectors located 'outside' the 'information economy', caused by either (a) having access to ICTs and the Internet, but not using this resource, or (b) not having the opportunity to use ICTs and the Internet, due to lack of access (NOIE 2002).

3 ELECTRONIC COMMERCE

The Internet has debatably revolutionised the way in which information is stored, exchanged and viewed, opening new avenues for businesses, which were only a decade ago almost inconceivable. This growing interest in the conduct of business transactions by electronic means through the Internet and/or dedicated networks; is often referred to as ecommerce (Anumba and Ruikar 2002). e-Commerce covers a broad area, conducted via a host of tools, instruments and systems, including telephone, fax machine, electronic payment and money transfer systems, electronic data interchange (EDI) and the Internet. The e-Commerce Model (Figure 3-1) illustrates the elements of the contemporary electronic commerce process (DIST 1998).

Figure 3-1: eCommerce Process Model



e-Business solutions enable local and international businesses to get online quickly and effectively over the Internet (DCITA 1998) and (IIB 2002). Australia and Queensland in particular are globally competitive, delivering world class e-Business solutions to a diverse range of local clients. E-solutions include online transaction services; brokerage services; integrated infrastructure management; data warehousing; e-Business system and software development; internet applications and ASP services; and consulting services (IIB 2002).

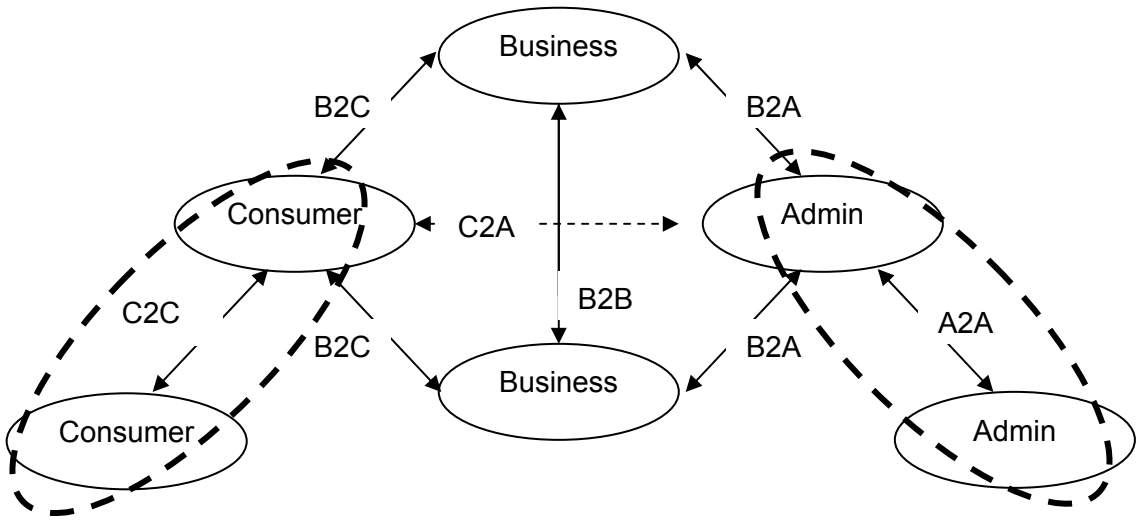
Research has identified six main e-Commerce categories, namely (Figure 3-2):

- **Business-to-Business (B2B):** an electronic means of carrying out business transactions between two or more businesses, incorporating everything from manufacturing to service providers – i.e.: electronic orders, receiving electronic invoices and making payments electronically. During the last decade, business-to-business (B2B) e-Commerce has

grown rapidly (DIST 1998), mainly because companies needed the related cost-savings and efficiencies to stay competitive.

- **Business-to-Consumer (B2C):** similar in concept to the traditional method of retailing. The main difference being the medium used to carry out business – i.e.: Internet.
- **Business-to-Administration (B2A):** covers all the transactions that are carried out between businesses and government bodies (e.g. details of government policies, initiatives and other information).
- **Consumer-to-Administration (C2A):** relatively new – e.g.: through various UK governments initiatives such as:
  - UK Online - a joint venture of the UK government with the industry, voluntary sector, trades unions, and consumer groups to facilitate Internet access to UK citizens. Facilities include e-Democracy, e-Voting, information about public services, e-Health, and publishing of advantages such as paperless offices, faster communications and reduced costs compared to traditional methods, etc.
- **Consumer-to-Consumer (C2C):** even though no financial transaction takes place, the exchange of value is still deemed as an internet-based economic activity (e.g.: e-Auctions); and
- **Administration-to Administration (A2A):** where future governments from different countries exchange documents and data or conduct business transactions electronically (Anumba and Ruikar 2002) and (Ecommerce 2002).

Figure 3-2: Six e-Commerce Categories



3.1 E-Construction

Today's construction industry and its participating organisations are making concerted efforts in taking up this innovative form of doing business via the internet, fortunately not without positive results, including:

- **Company promotion**: Architects, designers, fabricators, contractors and other members of the construction industry sector are using the Internet to promote their companies and inform people about the services they have to offer.
- **Product promotion**: The Internet is used for increasing product sales through online promotion. Product promotion is done either through an independent Web site or through an online vendor.
- **e-Procurement through Web directories and search engines**: The Internet is used as a tool to procure or obtain information about construction related suppliers and their

products. By entering keywords to search for a specific document or information (including jobs, products, specifications and bidding processes), the search engine returns with a list of the documents / locations where the entered keywords were found.

- **Project management**: Websites designed to streamline the construction business process by looking into how the Internet, used to improve and integrate the process of design and management of a construction project. Such a project management Website may speed up the process of communication between different parties involved in a construction project; thus avoid any unnecessary delays that are often a direct result of miscommunication.
- **Project collaboration**: Web-based project collaboration tools used to facilitate online collaboration for project partners and other stakeholders, allow them to communicate (exchange ideas, make comments, etc) in real time and from any location (defying the boundaries of time and geography).
- **Online tendering (e-Tender)**: The Internet has now made it possible to provide tendering information online along with project specifications (Anumba and Ruikar 2002).

A recent report on Technology Transition in the Engineering/Construction/Operations (E/C/O) Industry forecasts, "*E/C/O network projects will unquestionably be Web-hosted. Internet access to project information, and adoption of standards such as aecXML, will facilitate access to and sharing of information, leading to significantly reduced costs over the life of an asset. Estimating that between 5% and 10% of a project's total installed cost can be saved by Web-based data storage and more granular data access. Worldwide, such tools could save asset owners as much as US$400 billion annually by 2004*" (Daratech 2000).

The report further states, "*Web-hosted collaboration happens in one of two ways: through semi-public Internet portals* [a Web site or service that offers a broad array of resources and services, such as e-mail, forums, search engines, and on-line shopping malls] *such as Cephren, Buzzsaw and the like, or in private-trading-network extranets owned by the large engineering and construction firms. Semi-public portals will serve the smaller companies and those for whom it is not feasible to host their own sites. Private sites will be established by the large engineering – procurement - construction (EPC) firms, which can afford the infrastructure to safeguard sensitive projects and intellectual property as well as protect the identities of their trading partners*" (Daratech 2000).

3.2 Summary

The real impact of e-commerce is in delivering productivity and efficiency benefits through a transformation of business processes and forging savings along the value chains of industry sectors. Importantly, e-Commerce is not only seen as a way of cutting costs, but also as transforming business and creating new value chains. The challenges of implementing e-commerce are now better understood and estimates of potential benefits are becoming more realistic, underpinning productive growth in the economy. Needless to say, e-Commerce is more than 'simply putting up a website or implementing a system for electronic procurement', providing industry organisations with the means to 'inject' greater efficiency into tasks, such as data collection and data management, thereby freeing up company resources and requiring less focus on administrative processes and more on strategic activities (APCC 2001).

Current and future ICT and e-Commerce developments and their applicability and uptake within the public and private sectors of the construction industry, is causing virtually every business sector to shift away from traditional, tried and tested methods of communications, effectively revolutionising the way today's companies trade and conduct business. In Australia, some large organisations are well advanced in establishing their own portal sites for private or internal use, such as Project Services (Queensland) with their eProject site (Appendix III), and Bovis Lend Lease with their site ProjectWeb (Appendix IV).

Today there are already in excess of 180 ICPM Web sites or project management “portals” which have been established to service today’s AEC industry market requirements (Orr 2000). The more high-profile semi-public project portals can be viewed in Appendix IV, and include Autodesk’s Buzzsaw.com site, Bentley’s recently launched viecon.com site, and Cephren’s ProjectNet.com site. Companies such as BidCom, BricsNet, BuildPoint, CADX, Cubus, Meridian, and PrimaVera are also found to have a strong presence through sites such as Buildon Technologie’s projectCentre site; Meridian’s ProjectTalk.com site; IronSpire’s JobSite™ system; Constructware’s Constructw@re system; and Framework Technologies ActiveProject system (Crawford and Wilson 2000).

Although certain sectors and stakeholder groups within the construction industry are identified as embracing various ICT and ICPM tools and systems, the industry’s overall e-uptake is unfortunately very much reserved, especially when compared to other engineering sectors (e.g. automotive and aerospace industry). There are justifiably many reasons for this restricted uptake, two of the more ‘prominent’ being (a) the fragmented nature of the industry, and (b) the one-off nature of its projects (Anumba and Ruikar 2002).

Motivated by the above, one of this project’s research activities / deliverables (Section 1.2) include a detailed investigation in determining the local and international government and industry sector’s e-Commerce ‘current state-of-play’, including e-Tender and e-Archive activities. These findings are presented in a separate report.

4 ORGANISATION CULTURE

The following sections provide initial findings, outlines and definitions of certain industry, ICT and international culture types, personalities, etc. However, as outlined in Section 1.2, one of the project's research activities / deliverables entails the undertaking of a more detailed investigation in determining the 'current state-of-play' of local and international government and industry sector culture and ICT implementation barriers and needs that challenge organisations and project teams.

Therefore, findings on identifying and assessing human and cultural factors, limitations, barriers, and drivers as they arise from the nature of the AEC industry are presented in a separate report.

4.1 Organisational Culture

Every organisation within the industry has its own unique culture, character, nature, and identity. Referring to a report by (Michel 1998) whilst examining the current and future trends of the USA construction industry, he identified three basic types of construction industry organisation 'personalities' (Table 4-1).

Table 4-1: Construction Industry Organisation 'Personalities'

INDUSTRY CULTURE	ORGANISATION PERSONALITY
Undertakers	: tend to be uninspired achievers who leave everything alone.
Caretakers	: just flow with the tide and only take care of things that support its immediate environment. A short term outlook – '*if it ain't broke don't fix it*'
Risk takers (innovators)	: are the only ones who promote new technologies, new communication tools and take on new challenges head on. Contradictory to the 'caretakers' of the industry, risk takers '*will fix it even if it ain't broke*'.

From an international perspective, organisational cultures are divided into four culture types, namely: Family; Incubator; Guided missile; and Eiffel tower (Figure 4-1 and Table 4-2) (Joiner 2001).

Figure 4-1: International Organisational Cultures

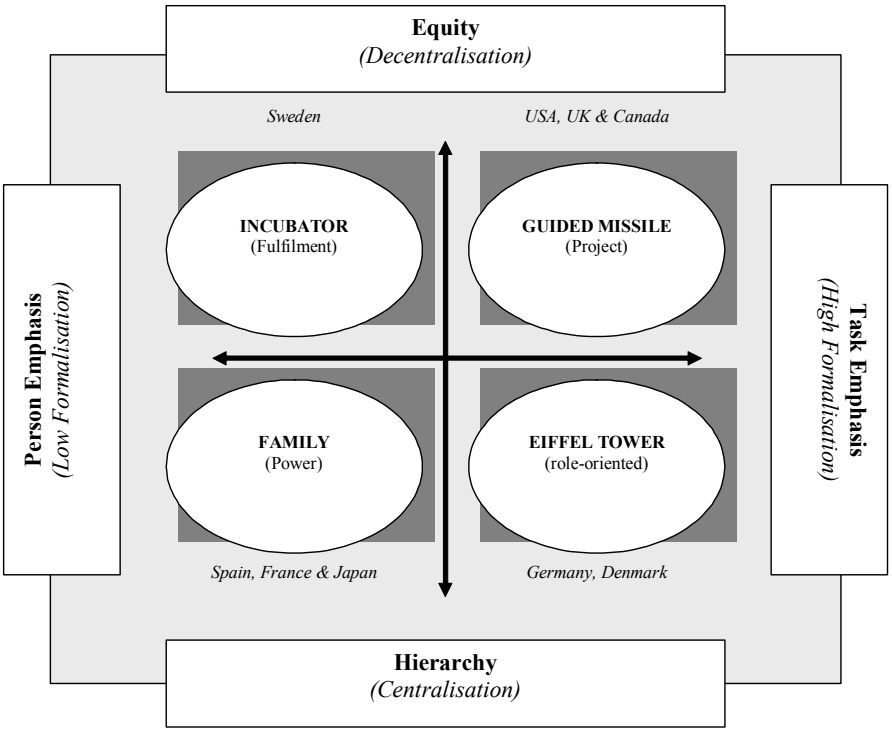


Table 4-2: International Organisational Cultures

	COMPARATIVE DESCRIPTION
The Family (power-oriented)	: characterised by strong emphasis on the hierarchy and an orientation toward the person. Individuals are expected to perform their tasks as directed by the leader, who may be viewed as the caring parent. Subordinates not only respect the dominant leader or father figure but they also seek guidance and approval.
The Eiffel Tower (role-oriented)	: strong emphasis on the hierarchy and an orientation toward the task characterises this culture. The 'Eiffel Tower' image symbolises the typical bureaucracy - a tall organisation, narrow at the top and wide at the base where roles and tasks are clearly defined and coordinated from the top. Authority is derived from a person's position or role within the organisation, not the person as such.
The Guided Missile (task-oriented)	: characterised by a strong emphasis on equality and an orientation toward the task ('getting things done'). Organisation structures, processes and resources are all geared toward achieving the specified task/project goals. Power is derived from expertise rather than the formal hierarchy.
The Incubator (fulfilment-oriented)	: characterised by a strong emphasis on equality as well as an orientation toward the person. The purpose of the organisation is to serve as an incubator for the self-expression and self-fulfilment of its members.

4.2 ICT Culture

Studying two large (non-construction) organisations (ethnographies) and their staff's historical relationships, experiences and interpretations of ICT, and by employing metaphors – i.e.: '*magic dragons*' (to represent ICT), and '*wizards*' (to represent ICT specialists) - enabled (Kaarst-Brown and Robey 1999) to identify five archetypes of ICT culture. Although this research was undertaken within two large USA insurance organisations, construction industry participants can channel their findings, lessons and recommendations, and apply them to current and future ICT implementation projects.

Even though the use of metaphors is regarded by some as 'never quite accurate', they are still accepted as an alternate, yet useful way to describe organisational cultures (Line 1999). With this said, the 'interpretation' of ICT cultures, as a form of 'twentieth century magic', is believed to lend insight into the variety of ways in which ICT is managed within organisations and their cultures; and reveal some of the dilemmas associated with successfully integrating ICT with business needs.

Figure 4-2 provides an overview of the strategy researchers used for analysing the data (pertaining to management and implications of ICT) from the two case study organisations. Importantly, the elements of each archetype culture were developed from both organisations – i.e.: neither organisation was associated with only one of the cultures outlined in Table 4-3.

Figure 4-2: Strategy for Developing Five ICT Cultures

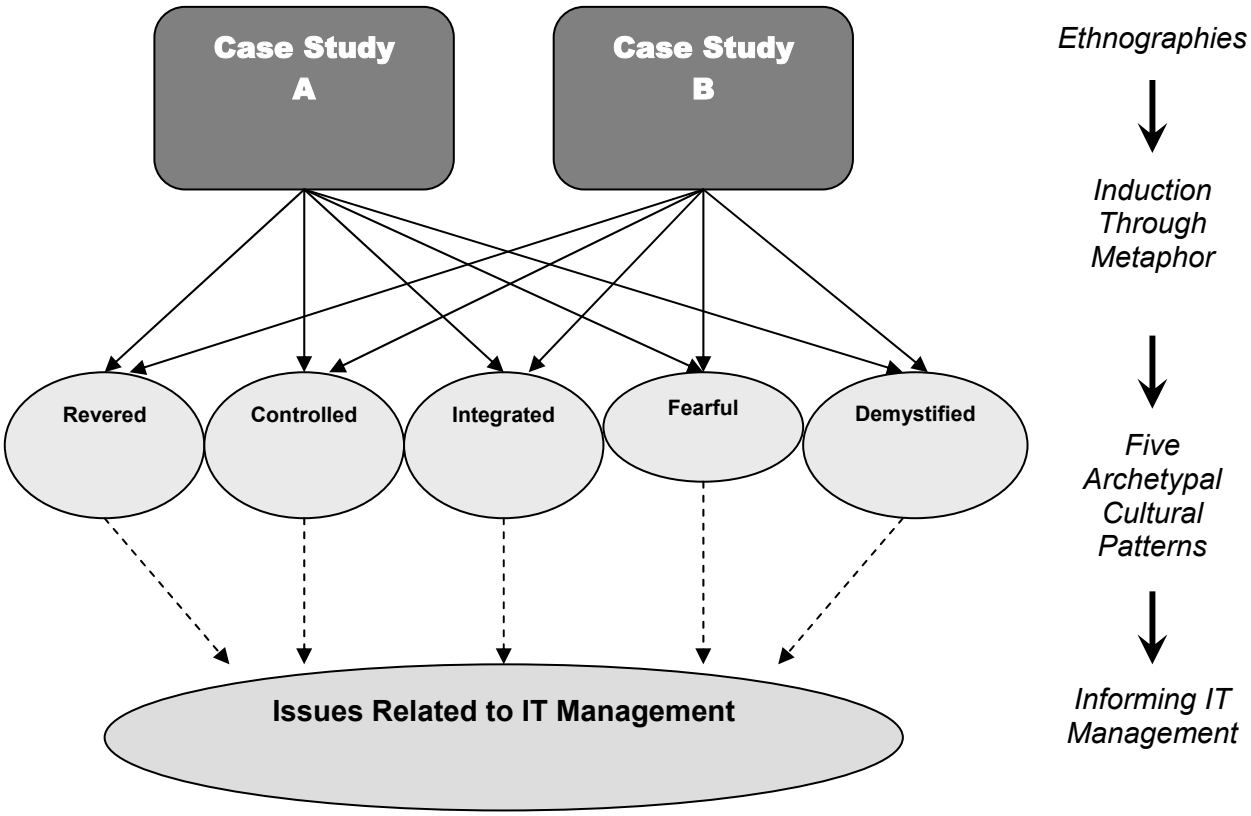


Table 4-3: Five ICT Cultures

FIVE ICT CULTURES		
METAPHOR	**DESCRIPTION**	**IMPLICATIONS**
Revered ICT Culture  *'Dragon on a pile of gold'*	• ICT has significant positive impacts for the organisation • Honours those responsible for introducing ICT (does not criticise technology) • Innovation and championship behaviours are encouraged to support continual improvement through creative, effective use of ICT • ICT knowledge, skills and resources belong in the hands of those who understand them • Able to overcome gender bias (technology skills is the key to prosperity and promotion)	• ICT innovations experience little resistance • Early ICT adopter stand to gain competitively by applying it to their business needs • organisation becomes compliant with its ICT 'superiority' - getting blindsided in a crisis (not support emerging business needs) • conflict between those who understand ICT and requirements for successful implementation and those who make the decisions • ICT 'wizards' disregarding user dissatisfaction and frustration
Controlled ICT Culture  *'Caged dragon'*	• Neither 'dragon' (ICT) nor 'wizard' (ICT specialist) are trusted enough to be 'freed' and their 'magic' (abilities) are to guarded and controlled • Senior management (centralised) control with minimal interaction with lower level end users • ICT specialists are deprived (caged) members of the organisation – minimally involved in strategic directions as they are perceived by senior management as not having the necessary 'business knowledge' to understand strategic application of ICT, therefore receive and control few resources • ICT perceived as a 'necessary evil'	• Found to allow better integration of ICT and business strategies • Intensified competition resources between management and ICT specialists – 'whoever yells the loudest wins' • Lack of senior management ICT knowledge and skill effects innovative decision making – ICT aloud limited opportunities to influence strategic planning • Fail to develop adequate ICT skills • Senior management (usually older) tend to smother the (perceived threatening) ICT creativity of younger managers
Demystified ICT Culture  *'Pet dragon'*	• Inexperienced ICT specialists are unaware or unappreciative and only partially in control of ICT capabilities or opportunities • realising their own employment future depends on it, business employees are more aware of what ICT has to offer and develop / implement themselves - without accessing ICT resources ('self proclaimed wizards')	• ICT identification and application opportunities (and risks) realised through recruitment of employees that are 'self sufficient', 'independent' and 'self proclaimed' ICT 'wizards' and users • Discouraged reliance on ICT specialists • users solve their own ICT problems • tension between fragmented / duplicated ICT efforts of users and ICT management
Integrated ICT Culture  *'Team Dragons'*	• ICT, the specialists and users place equal value on each other's skill and capabilities (independently competent yet reliant on each other) – creating a positive and creative experience shared by all. • Business goals and client needs drive ICT innovation • Not widely supported	• due to ICT users and specialists willingly working together, ICT solutions to business problems can be positive achieved • teams do not necessarily function well simply because they were formed – e.g.: an innovative ICT is developed by specialists but poorly implemented by management / potential end-users • hard to sustain commitment is required • hidden agendas and problem solving rituals will cause the teamwork concept to fail.

Fearful ICT Culture
 
'Dead dragon'
	• rely on manual information processing (even if ICT is available and proven capable)
	• resist / mistrust ICT (automation) based on various rationales:
	  • inability to replace human intuition;
	  • inaccuracy of tool/ system processing;
	  • difficulty to correct tool / system errors; and
	  • mistrust of developers
	  • fear
	  • lack of knowledge, experience and skills
	  • introduce unnecessary risk
		• ICT mistrust may emphasise a greater concern for people – placing an innovative ICT under close scrutiny
		• Tend to continue manually until all ICT flaws are detected, corrected and potential benefits were realised by all
		• Transition from manual to automated to be gradual and 'as easy as possible for employees
		• Invest significant resources in training
		• Continued fear of an implemented ICT system limits further innovation and leads to under-utilisation

4.3 Summary

Because culture has its own history of success, which reinforces and strengthens the organisation's way of doing things, the global competitive business environment has made the culture of an organisation a critical aspect of its success (Sadri and Lees 2001). Older and more successful organisations tend to have stronger cultures, natures, and identity, by way of ‘communities’ of people that have a mission and machine-like characteristic that serve the needs of the immediate and wider organisational community (Schneider 2000; Meudell and Gadd 1994).

Furthermore, organisations that have the supposed ‘optimum’ ICT implementation strategy may (in some cases) find it worthless. That is to say that if the organisation’s culture is not properly aligned with, and supportive of, the implementation strategy, the strategy will either stall or fail (Schneider 2000). Organisations, as members of the largest productive industry of any developed country, need to find the ability to trust each other again, and break away from the ‘undertaker’ or ‘caretaker’ approach to ICT innovation, and become more ‘risk takers’. Unfortunately, this transformation of personalities is not easy, hindered by the industry’s exceptionally fragile level of ‘trust’ (Section 5.3.3), which is currently replaced by fear of litigation (Michel 1998).

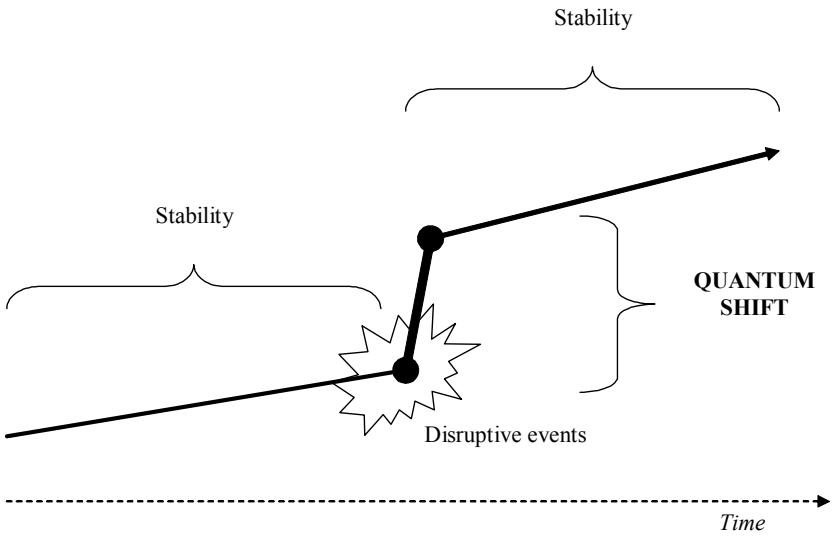
Therefore, one of the last available ‘mechanisms’ left for organisations to improve their competitive position within the construction industry is by considering people (human resources) along with technology. By employing a dedicated, highly skilled, flexible, co-ordinated, committed and productive workforce, coupled with a leaner, flatter and more responsive organisation will ensure a more effective and successful implementation of innovative ICTs (Morley and Heraty 1995).

5 ICT and CHANGE

At the beginning of the twentieth century, the 'industrial era' was born through a 'quantum shift' - from an agricultural to an industrial economy (Figure 5-1). As a result, original ways of working and techniques for managing complex organisations had to be changed, consequentially causing the rise and continuous improvement of mass production tools (efficiency) and classic management techniques ever since (Youngblood 2000):

- 1960s: Innovation - challenging the established norm;
- 1970s: industrial strife and conflict between employer and employee;
- 1980s: enterprise culture with strategic alliances and privatisations; and
- 1990s: short term contract, outsourcing, flexible workforce and a long 'working hours' culture (Cooper 1999).

Figure 5-1: Disruptive Events (Change) - Causing a 'Quantum Shift'



5.1 Industry Need

Today, the development of ICT can be compared to that of the industrial revolution, where the predictions of its impact on society are described as being 'bewildering and controversial' (Ahmad 2000). Many ICT and systems managers of firms are sometimes 'seduced' by new technologies, 'blinding' them from being focused on the real reasons and need for change (Hee 1998).

The success and survival of industry organisations will depend largely on how 'valuable' strategic principals are developed, adopted and acted upon in the wake of technological change or ICT 'revolution' and how the industry's contains its increased 'dependency' on the 'connectivity' of the Internet. As a result, some of the impacts facing industry organisations include:

- **Hectic pace:**
  New process innovations and product introductions have accelerated. Product life cycles are becoming shorter. New industries are emerging. What made a business successful may not keep it successful in the end. Sayings like '*Don't fix it if it isn't broke*' is changing to '*If you have been doing it the same way for the past 20 years, chances are you are not doing it right anymore*'

- **Increased productivity:**
  More work can be done in less time. The cost of time may go up as a result. Mistakes will get costly too. The demand for higher quality and 'zero defects' will increase. The traditional client-designer relationship may change. Clients will demand fast turn-around times, while designers will be competing among themselves for creative designs and quality products.
- **Legal infrastructure:**
  A new legal infrastructure for contracting and doing business using ICT and the Internet will have to evolve. Different standards and meanings will come into play in cyberspace regarding such issues as signatures, time stamping, intellectual property, privacy, liability, and jurisdiction.
- **Power of knowledge:**
  ICT education will somehow have to be incorporated as a supplement to technical knowledge and expertise in various fields. The workforce of the A/E/C industry will have to embrace the ideas of on-the-job education, continuing education, and part-time graduate study.
- **Creative destruction:**
  ICT and the Internet enable industry participants to bypass many business functions. Many '*reinventing-the-wheel*' type functions will become obsolete within the organisation as well as the industry. The demise of certain functions may give rise to uneasiness and resistance in the industry. Yet this phenomenon should be viewed as '*creative destruction*,' since new and better ways of doing business are replacing old and unnecessary ones.

5.2 Technology Driven Change

The 'impacts' of technological change – i.e.: where new technologies (eg. ICT), coupled with significant organisational change and skills development - can improve performance characteristics of construction:

- **Production process (as a whole)**: the total process, current levels of inefficiencies and waste materials, could reduce labour and time, as well as pollution in half - by streamlining supply chains and through the introduction of better management practices. New ICT systems could improve performance and help integrate briefing and design decision-making and improve 'flexibility' to meet customer needs.
- **Output**: it is unlikely that construction output will increase. However, new construction activity could be stimulated (with additional investments made), if significant cost reductions can be achieved through technical and organisational change.
- **Employment**: technical (e.g.: ICT) innovation aimed at improving performance, is likely to have serious consequences for employment, training and recruitment.
- **Productivity**: when considering the total process (from initial client discussions to completion and operation of facilities) there is vast room for performance improvement (directly related to technical and managerial competence). Successful demonstration projects have illustrated major performance benefits through the implementation of new ICT systems (for coordination and control) together with component-based approaches in construction.
- **International competitiveness**: the development of further technical (and ICT) capabilities in international construction and consulting design and engineering firms could increase export markets.
- **Quality of products**: technical change in materials, components and systems integration could improve physical and aesthetic durability, and reduce embodied and life-cycle energy costs.
- **Cost and prices**: technology is one of a number of factors affecting construction prices. Unless these costs and prices are kept under control, construction is likely to loose support through substitution for other investment industries and commodities (Gann 1997).

5.2.1 Resistance to Technological Change

Change can be effected by strengthening the driving forces, or by weakening the restraining forces, or both – i.e.: by (a) 'unfreezing' existing forces, (b) introduce change (geared to re-establishing the 'equilibrium of forces') and then (c) to 'refreeze' the new situation. However, strengthening the driving forces without weakening the restraining forces is likely to place strain on the system (Buch and Wetzel 2001). The use of Table 5-1 is recommended as a tool to compare an organisation's driving forces against the restraining forces in order to determine any 'resistances' to change (e.g.: implementing an innovative ICT).

Table 5-1: Forces of Resistance to Organisational Change

DRIVING FORCES	RESTRAINING FORCES
• Dissatisfaction with current situation and acceptance	• Fear of the unknown and feelings of insecurity about need to change
• Impact of environmental factors	• Disruption of routine and usual patterns of behaviour
• Momentum towards change – the domino effect	• Loss of face
• Motivation by consultant	• Threat to the power base and other vested interests
• Commitment of top management	• Blindness to the need to change • Group norms and values

Supporting the above recommendations in how to deal with the forces of resistance, (CRISP 2000) suggests a similar 'force-field' analysis be implemented – i.e.: to map the driving and restraining forces to technological change (Table 5-2).

Table 5-2: Technological Change Force-field Analysis

DRIVING FORCES	RESTRAINING FORCES
Innovation	Time to market
Cash for knowledge	Competition
Long term cost benefit	Initial development cost
Competitive advantage	Risk of failure
Time saving	Initial development time
Quality improvement	Awareness of track record
Education	Knowledge sharing
Financial incentive	Understanding of process

Moreover, it appears advantageous for implementers (e.g. of an innovative ICT tool or system) not to 'camouflage' the true nature of a change prior to its implementation – i.e.: not to portray the change as less dramatic and positively beneficial to the staff and the company. This 'clouded' staff 'programming' is the grounds of resistance towards technological change (Hughes et al. 2000).

5.3 Culture Driven Change – '*Technology Is Not Enough*'

'When we know what culture is, we know what needs to be changed for culture to change. Only once we appreciate its nature can we understand how it might be changed'. (Lewis and Thornhill 1994; Sadri and Lees 2001).

Although attempting to align the implementation of innovative ICTs with organisational (cultural) change is not a new phenomenon, it is not an easy task (Uren 2001). According to leading UK ICT researchers and consultants (Cabrera et al. 2001), 80-90% ICT projects fail to meet their performance goals due to organisations giving inadequate attention to non-

technical (human and organisational) factors - termed 'critical determinants' of new system effectiveness. Organisations must realise when undergoing a technology (ICT) driven change, that ICT is only one of several inter-related components which drive organisational performance. Organisations must be able to efficiently manage the changes imposed (e.g. from introducing a new ICT) in such a way as to minimise the human costs of the transition while maximising the benefits from the technology. Successful technological (ICT) innovation and implementation requires that either (a) the technology be designed to fit industry organisation's current structure and culture or that (b) the organisational structure (processes) and its culture (people) be reshaped to fit the demands of the new technology.

Furthermore, when considering the implementation or adoption of new ICTs into long-established organisational arrangements and multiple work cultures, one can not assume once electronically and simultaneously linked, that it will automatically ensure an increased sense of community, improved ability to collaborate or improved understanding of others (Graham 1996). As such, companies who wish to become that 'excellent' company and experience increased competitive advantages may very well have to simultaneously introduce a 'cultural change program' that gradually 'cultivates' the existing culture to accept change. However challenging or far reaching the essential results may seem, they are achievable by implementing the following 'change program activities' (Lewis and Thornhill 1994):

- **Defining the desired goals:** described as the difficult task of defining clear, measurable, and time-specific goals of attitudes, beliefs, and behaviours of personnel.
- **Analysing the current state:** referring to earlier research (Lewis and Thornhill 1994) recommend this form of analysis can be achieved by comparing the organisations driving forces against the restraining forces (Table 5-1) – i.e.: factors likely to promote change to those factors likely to hold back change.
- **Reviewing the change strategies available:** various approaches to achieve organisational change are to be considered.
- **Deciding on the appropriate strategies:** even though this is proven to be a difficult task, answers to the following questions are potentially useful when deciding on which strategy to adopt:
  - *Are the strategies likely to gain the support of those who will play a part in their implementation (particularly senior and line managers)?*
  - *Do the strategies have the potential for yielding useful data quickly?*
  - *Have I and others (involved in the process of data collection), sufficient expertise to conduct the strategy successfully?*
  - *Are the strategies too expensive and time-consuming?*
  - *Are the strategies likely to involve those concerned with the implementation, being embroiled in organisational politics?*
- **Implementing and evaluating the strategies:** based on (a) the answers to the above questions, (b) continuous monitoring and (c) ending with a thorough review.

5.3.1 Invest in People – '*Respect, Recruit and Retain'*

In an attempt to 'radically improve' the industry's performance on 'people issues', a working group was set up in the UK and charged with identifying practical and effective ways in which the construction industry could improve its performance (Rethinking Construction 2000). Research outcomes identify the 'failure' of leading firms 'respecting people' potentially caused irreparable damage to their 'bottom line'. In addition, the 'gap' between the 'respect' demonstrated towards operatives (blue-collar workers), and that shown for white-collar workers (management), is identified as perhaps most damaging of all.

Research findings suggest the most urgent business challenges currently facing the industry is not the implementation of innovative technologies (e.g.: ICTs), but rather the need to 'look after people'. Companies who fail to improve their attitude and performance towards

respecting their own people and others, will fail to **recruit** and **retain** the best talent and business partners (Rethinking Construction 2000). This challenge is also recognised in (Linowes 1999) where '*holding on to good people'* is regarded as today's management challenge.

5.3.2 Shared 'Ownership'

People are (generally) more committed to plans and activities (e.g. implementation of an innovative ICT) when they share the ownership of those plans. This 'employee participation' is essential, because any organisational policies and plans will have an impact (in one way or another) on their 'working' lives (Baines 1998). Yet, on the other hand, these 'ownership cultures' can also fail due to:

- Employees having 'initiative fatigue'.
- Even though employees are generally / initially receptive, they may not understand the 'proposal' due to it being too complex, unconventionally written (too technical) or presented (different format).
- 'Managers listen - yet do not change' as they may be threatened by perceived 'disempowerment'.
- New or Improved plans, suggestions, recommendations, alternatives, methods, etc., are not supported by appropriate and timely actions from decision makers.

The renewed respect and involvement of organisational and project personnel are supported in (Rethinking Construction 2000) – i.e.: to ensure improved and overall performance, it is important to involve, engage and empower all people in issues that directly affect them. Further supported in (Graham 1996) stating 'non-technical people' need to take their share of responsibility to 'bridge the gap' between those who invented / developed work supporting technologies (e.g.: ICTs) and those who 'criticise' innovative technologies as 'unappealing' and 'unsupportive' of their work.

5.3.3 Trust and Teams

Due to the 'complex and turbulent' nature of today's global business environment, a move towards 'team-based organisations' is suggested by changing the way people currently interact and work within industry organisations. Furthermore, the success of implementing these 'autonomous' / self-directed / cross-functional working teams (to boost effectiveness and productivity) is dependant on conducting an organisational culture and structural analysis prior to its implementation (Tata 2000) and (Unknown 1997). Yet, although many organisations believe and trust in the teamwork concept of: having regular team meetings; sharing of ideas; experiencing 'spirit' of team work; and realise the potential benefits it can bring, it is not easily achieved or maintained (Hiley 2001).

The construction industry is an integral part of any country's business environment and its 'problems' lie with all its participants, not just the '*hard hats*'. These 'problems' can be overcome if industry participants simply learn to trust each other (Michel 1998). The current lack of being able to trust each other (e.g.: due to the fear of litigation, etc.) has caused the industry (as a whole) to go from '*risk takers*' to being '*caretakers*' (Section 4).

There were three men doing the same task on a construction site. When asking them what their task was, the first replied 'breaking rocks', the second 'earning a living' and the third 'helping to build a cathedral' (Michel 1998).

To ensure a successful and effective project team, it needs to be embraced by its members as a 'total discipline' – i.e.: applied constantly; during formal and informal discussions; in times of project related (as well as personal) crisis; and any other everyday interactions (Hiley 2001). Therefore, the industry is advised to develop an 'indisputable code of ethics'

that emphasises integrity and trust in all its activities, thereby encouraging an increase in its participants to '*help build cathedrals*' rather than continue to simply '*break rocks*' (Michel 1998).

5.4 Summary

Construction organisations are faced with many new challenges, including the need to change current work practices; become more client orientated; become more competitive; and become more productive (Love 1996). These challenges are attributable to factors that effect the working environment, including globalisation of the economy; greater performance expectations from the clients; increased competition between local contractors; continued restructuring of work practices, and industrial relations.

The industry has to realise that investing in ICT is no longer primarily buying a piece of hardware or software. It is now more of a potential long term investment in the process of change itself (Cleveland 1999); (Buch and Wetzel 2001). Unfortunately, the nature of the industry's constructed products, its organisations and processes, limit technological change within the industry (Gann 1997).

Therefore, achieving a balance between the industry's need and organisational cultures is a 'key construct' in understanding and managing the behaviour of people within the boundaries of an organisation and in implementing a technical (ICT) driven change (Cabrera et al. 2001). Successful ICT implementation requires careful consideration to the 'human touch' by determining new / improved ways of innovating the user, not only the technology (Gore 1999; Ahmad 2000; Claver et al. 2001). This will inevitably result in a firm or project experiencing previously unknown increased levels of professionalism and benefits, including:

- a better standard of work;
- more cost effective projects;
- fewer delays and expensive mistakes;
- fewer accidents and less ill health;
- reduced staff turnover;
- earlier completion dates;
- an advantage over competition; and
- increased repeat business (Rethinking Construction 2000).

6 ICT IMPLEMENTATION ADVANTAGES and DRIVERS

Measuring the benefits of ICT innovation and its implementation within the construction industry is not easy. This, according to (Andresen et al. 2000), is due to there being numerous methods of its evaluation (none with a consistent approach within or across industry organisations) – i.e.: several based on traditional investment appraisal techniques (primary financial ratios) and others adopting a more subjective approach. ICT benefits can only be realised fully when the various technologies and systems are applied to specific and relevant tasks across several organisations and projects.

This section of the report provides advantages and drivers (identified by various international R and D activities), which may encourage individuals and industry organisations to readily adopt innovative ICT tools and systems.

6.1 Industry Perspective

When it comes to assessing the use of ICT within the AEC industry, there are a number of implementation barriers identified:

- lack of people with an 'overarching' vision for the industry;
- fragmented and adversarial nature of the industry;
- lack of trust among firms;
- lack of shared language in which to understand the supply chain process; and
- lack of shared / common / compatible technology (Fujitsu Centre 1998).

To further understand how ICT can provide long term benefits to the industry, by utilising ICT to create new ways of doing business and building value-added competitive advantages, (Fujitsu Centre 1998) established that the 'automation' of existing work practices provide a range of general benefits, including:

- **productivity gains** - companies who have re-engineered their business processes along with the adoption of ICT experienced significant gains in productivity and competitive advantage by enabled expansion into new markets and positioning them to compete internationally – i.e.: creating networks based on ICT across organisational, national and international boundaries;
- **increased business turnover**;
- **shorter cycle time** - a perception that ICT provides an expectation of faster cycle and response times;
- **systems to manage larger and more complex projects**; and
- **improved accuracy and consistency** of documentation.

Today, many organisations are increasingly offering e-Commerce services and solutions and taking advantage of the current inefficient methods of communication and data exchange within the construction industry. This positive infiltration is made possible through the use of Web-based solutions for communication and project management, resulting in increased efficiencies in project communications, leading to overall time and cost savings (Anumba and Ruikar 2002). Using e-Commerce in the construction sector can reduce paperwork; lessen re-keying of information; reducing errors; and provide a wider market reach. Further advantages include:

- **Company / product promotions**: Using the Internet to promote a company or its products can facilitate:
  - a reduction in advertising and marketing costs;
  - provision of company information (products and services) through a Web presence;
  - easy access to target audiences from the construction sector; and

- transparency with customers.
- **e-Procurement through search engines and Web directories**: Advantages include:
  - quicker access to construction-related information;
  - up-to-date product and industry information;
  - simplified procurement business processes;
  - cost savings through disintermediation; and
  - quicker product comparison in terms of price and quality.
- **Project management / online project collaboration**: Online collaboration tools can facilitate:
  - improved management of construction projects;
  - easier access to project information from anywhere at anytime;
  - faster transaction time;
  - enhanced transparency in the exchange of project information;
  - better collaboration between construction project partners;
  - increased time savings for communication of project information;
  - amplified savings on project cost; and
  - streamlined construction business processes.
- **Extranet:** The primary advantages of an extranet-based system include:
  - allowing various agencies in a region to work together via the Web;
  - establishing costs of the integrated system are low;
  - users have a choice of software and operating systems to communicate effectively;
  - provides open standards – i.e.: no need to concern with equipment compatibility;
  - minimal training is needed to understand the function of the system; with
  - relatively minor system maintenance requirements (Smith and Scherer 1999).
- **Virtual Reality (VR) Technology:** The use of simulation techniques (VR) can be helpful at the early stages of projects (Gann 1997). VR systems can provide a variety of advantages, including:
  - for client briefing;
  - bringing together / involving different interested groups located in different parts of the world in the planning process;
  - reduce risk and uncertainty in design decisions;
  - improve predictability decisions;
  - lower cost for making changes; and
  - saving time.
- **Digital Cameras and Video:** The implementation of digital cameras and video conferencing tools and systems, allows industry organisations to succeed in today's ICT dominated world, by enhancing and maintaining business and personal relationship on projects, whilst continuing the traditional 'face-to-face' approach of doing business (Linowes 1999). The ability of this 'enhanced, long distance, remote and face-to-face collaboration' amongst projects and team member organisations (through the use of visual facilities) is supported in (Graham 1996).

6.2 Organisational Perspective

Forces that drive construction industry organisations to adopt new ICTs include:

- **Competitive advantage**: The managerial goal of competitive advantage and keeping up with technology exists when:
  - the new technology improves a critical organisational capability; and
  - most competitors do not use a similar technology - as more competitors adopt a technology, the 'uniqueness' and 'differentiation' that early adopters had will be lost.
  - Additionally, better management of risk is required by:
  - thoroughly specifying the technological capabilities required;
  - selecting a technology closest to their needs; and

- following an implementation strategy that maximises the probability of success, rather than minimising the risk.

- **Process problem:** the adoption of a new technology can be driven / initiated by a 'problem' – i.e.: a 'mismatch between the required level of performance (cost, schedule, quality, safety, etc.) and the actual performance'.
- **Technological opportunity**: a '*technological push force*' where the technology adoption is 'solution driven' – initiated by the identification of a technology, not a particular need or improvement goal. Organisational factors that increase the technical and financial feasibilities of an ICT include:
  - increased organisational capabilities;
  - availability of complimentary technologies; and
  - reduced cost of technologies.
  - identification of potential long term and short term benefits: initiates the decision-making process;
  - availability of 'slack resources': enables adoption of the technology (on a limited bases) without much need for cost justification; and
  - availability of organisational capabilities: reduces the cost of the technology and the lack of resources required.
- **External requirements:** Contractors with low technological capabilities and reactive attitude towards technology are found to be more sensitive (greater probability) to adopt a technology because of external demands such as:
  - Clients: often specifying project control technologies such as scheduling tools, cost control systems and email.
  - Competitors: the need to remain on 'equal footing' with competitors and identified technologies which have become industry standard. Further stating that a new technology used by competitors would not be adopted unless the technology gives the competitor a distinct advantage.
  - Regulatory agencies: although not necessarily influencing the use of a specific ICT they can drive the use of other technologies e.g. the use of safety technologies for occupational health and safety administration, etc (Mitropoulos and Tatum 2000).

6.3 Project and Stakeholder Perspective

The supply of appropriate and accurate information to the right people (when and where it is required) is a critical on any project. As a result the development and use of ICT systems has become the most important technology for the improvement of the construction process – i.e.: to support decision making in projects from early planning and conceptual stages through design, engineering and procurement, to erection, installation, commissioning, operation and facilities management (Gann 1997). Although there are many technical and implementation problems associated with the introduction of ICT to the construction process, the following benefits can be experienced:

- Better integration of information flows between different firms in projects;
- Automation of routine information processing and communication activities within project teams; and
- Production of new information providing new levels of transparency about processes and facilitating further process improvements through the ability to acquire new knowledge, generate feedback and learn.

Further benefits that can be realised through the adoption of innovative ICT solutions by industry professionals, consultants, suppliers, manufacturers, and SMEs, include:

- **Architects:**
  - automated design and documentation;
  - electronic support for project administration;

- support for presentation and marketing of design through rich multimedia software tools – i.e.: ability to demonstrate design using virtual reality simulation;
- electronic document management;
- significant productivity gains; and
- ability to integrate work flows with increased levels of detailed design;

- **Quantity Surveyor:**
  - increased productivity through streamlined data entry and data management;
  - increased productivity through automated quantity and cost calculation;
  - faster measurement through use of digitisers;
  - elimination of measurement through direct calculation of quantities from CAD files; and
  - faster transmission of quantity and cost via email.
- **Consulting Engineers:**
  - support for calculation in analysis and design through specialist calculation tools;
  - use of email for communication with business partners;
  - use of advanced modelling tools to support more accurate analysis and design and meet performance-based design criteria – the development of IT-based design packages linked to analyse programs and drawings on previous standard details, has meant that documentation is increasingly becoming semi-automated;
  - documentation of building structure and survives using CAD;
  - use of computer-based workflow management and document management to improve quality assurance;
  - the development of knowledge-based systems in design and integration of design and cad documentation processes; and
  - joint venture opportunities with groups who have complementary design capabilities thereby providing single source solutions.
- **Principal and Specialised Contractors:**
  - electronic tendering with greater efficiency and accuracy in estimation;
  - better project planning using 3D and 4D planning and scheduling software;
  - better inventory management and reduced costs;
  - computer-based workflow management;
  - better contract / project management through data sharing, and document management;
  - elimination of duplicate effort through improved access to information;
  - better project control and coordination due to access to the latest / up to date information;
  - better accounting / budgetary control and cash flow management;
  - use of global positioning systems (GPS) for setting out;
  - Improved safety management through the use of database systems;
  - Cross-sectional integration to provide single source approvals;
  - sourcing of components and materials using IFC's and from the Web;
  - increased turnover;
  - faster and cost effective communication with IT investments to pay for itself within two years;
  - manage projects despite large distances between the head and site offices – including real time audio and visual linkage;
  - overcome shortages of skilled workers by integrating processes through extensive use of IT in off-site pre-manufacture processes;
  - early detection and resolution of problems related to project management; and
  - significant reduction in rework and duplication.
- **Building Suppliers and Manufactures:**
  - integrated systems for optimising ordering and despatch;
  - integration of product design and manufacture – high productivity and efficiency with shorter product development times;
  - use of robotics to fabricate complex components and sub-assemblies off-site;

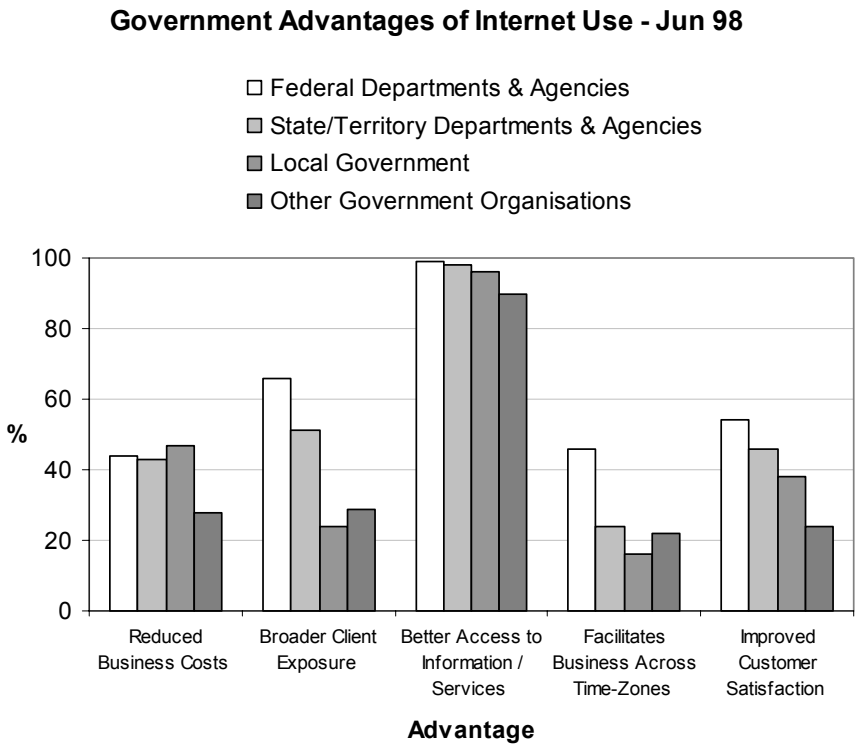
- logistics and inventory management systems – just-in-time management of logistics and inventory;
- Internet / Web-based customer and supplier interfaces;
- electronic tendering;
- executive information system for retail management;
- sales force automation for mobile access to corporate / customer databases containing timely and customised business information for management and marketing – improved customer service;

- **Small-To-Medium-Sized Enterprises (SMEs):**
  - ICT offers consultant and contractor SMEs the same opportunities and potential benefits as those listed above for the larger enterprise architectural, quantity surveying and engineering sectors. The most significant challenge facing SMEs is the skilling of small organisations in the use of ICT (DCITA 1998; Fujitsu Centre 1998; Foresight 2000; Lau, Wong et al. 2001).

6.4 Government Perspective

Research shows that almost all (95%) Australian government organisations with access to the Internet (June 1998), identified 'better access to information/services' as a benefit of the Internet (Figure 6-1).

Figure 6-1: Government Advantages of Internet Use – June 1998



A lower proportion of organisations experienced benefits such as 'reduced business costs' (39%); 'broader client exposure' (37%); 'improved customer satisfaction' (36%); and 'facilitates doing business across time zones' (23%). 'Broader client exposure' was reported more often as a benefit by Federal departments and agencies (66%) than by State/Territory (51%) or local government (25%). 'Improved customer satisfaction' was reported as a benefit by 54% of Federal, 46% of State/Territory, and 38% of local government organisations. Finally, only 1% of organisations with access to the Internet reported 'no benefits' to Internet use (ABS 1999).

6.5 Summary

Generally, ICT applications are 'confined' to each sector of the industry, and any benefits experienced restricted to that sector. These cross-sector ICT benefits are threefold:

- First, ICT is used to **improve the efficiency**, speed and quality of communication across sectors, thereby reducing cycle times and increasing quality for the whole supply chain.
- Second, ICT can be used to facilitate the creation of a **transformed supply chain** by taking a different approach to cross-sector relationships. By encouraging greater concurrency between tasks conducted by firms in different sectors through increased sharing of information can ultimately achieve substantial savings in time and money for the client.
- Lastly, ICT can **increase the total value** of the project to the client (operator) through improved sharing of information and knowledge between, for example, the design team, contractor and suppliers, encourages collaboration in identifying new and improved solutions to unforeseen problems on a project (Fujitsu Centre 1998).

Factors associated with successful adoption and implementation of ICT includes:

- taking an incremental approach to ICT implementation;
- ensuring new ICT systems have business benefits;
- changing / re-engineering the organisation to take advantage of the technology;
- use of individual projects to fund incremental adoption and as an opportunity to learn to use the new technology;
- training and development of staff to be able to use the technology successfully; and
- top-level management 'buy-in' (Fujitsu Centre 1998).

7 ICT IMPLEMENTATION BARRIERS and CHALLENGES

This section of the report highlights various barriers and challenges experienced during the implementation and application of innovative ICT tools and systems within the construction and other industry sectors.

7.1 Industry Perspective

A large number of risk factors or impediments are associated with the unsuccessful adoption and implementation of ICT. The following implementation challenges need to be recognised and overcome by the overall industry:

- high cost of innovating or learning a new technology - due to tight margins for funding;
- fear of over-investment in ICT;
- industry reluctance to invest sufficiently;
- belief that ICT alone (without re-engineering / organisational change) can deliver promised benefits;
- resistance to reengineering / organisational change;
- lack of computer skills and awareness of opportunities;
- belief that ICT innovation is not necessary - that the industry is doing sufficiently without it; and
- client, senior partner and manager resistance (Fujitsu Centre 1998).

In spite of all the benefits e-Commerce provides, in order to increase construction industry and public confidence in adopting these innovative ICT applications, (Anumba and Ruikar 2002) identifies the following two barrier categories:

- **General / common**: these mainly fall into three categories:
  - Infrastructure: although the Internet is referred to as a 'global phenomenon', the telecommunication infrastructure of several developing countries is insufficient to compete with their developed counterparts.
  - Trust and reliability: confidentiality, authenticity, integrity, security and proof of transaction must be developed and maintained.
  - Regulatory issues: unclear regulatory issues (e.g. tax, legal, financial, market access and ethical) are deemed 'major deterrents'.
- **Construction specific**: due to industry operations – i.e.: using '*arms length contractual relationships*', where the temporary nature of teams and relationships are formed only for the duration of a project - provides little incentive for investing in innovative ICT's such as eCommerce. Additional factors that limit the uptake of eCommerce in the construction industry include:
  - high cost of initial investment associated with building;
  - required infrastructure;
  - training of personnel;
  - quantifying the return on investment;
  - security of data; and
  - interoperability of software applications.

7.2 Organisation Perspective

The top barriers to computer use by Australian businesses (June 2000) were:

- 'not suited to nature of business' (48% of businesses without computers) - down from the 63% at June 1998;

- ‘lack of skills/training’ (37%) - up from the 28% at June 1998;
- ‘costs too high’ (24%) - down from 32% at June 1998; and
- ‘lack of interest’ (21%) - not included in past surveys.

Furthermore, an estimated 126,000 Australian businesses with computers did not have Internet access, of which the top barriers to Internet use were:

- ‘not suited to nature of business’ (54% of businesses with computers and no Internet access) - down from the 60% reported at June 1998;
- ‘lack of interest’ (26%) - not identified separately at June 1998;
- ‘lack of skills/training’ in the use of the Internet (23%) – similar 24% at June 1998;
- ‘costs too high’ (19%) - down from 30% at June 1998; and
- ‘security concerns’ (17%) - not identified separately at June 1998 (NOIE 2001).

Organisations are face with increasing and long-term business process ‘disruptions’ caused by innovative ICT applications (Revenaugh 1994). These disruptive ICTs, and how they affect industry organisation traditions, are shown in Table 7-1:

Table 7-1: Affects of ‘Disruptive’ ICTs

TRADITIONS	‘DISRUPTIVE’ ICTs
• Information appears in only one place at one time	• Shared databases (Internet, Intranet, Extranet, etc)
• Only experts can perform complex work	• Expert systems
• Businesses must choose between centralisation and decentralisation	• Advanced telecommunication networks
• Managers make all the decisions	• Decision-support tools (database access, design and modelling software, etc)
• Site / field personnel need offices where they can receive, store, compose and transmit information.	• Wireless data communication (WAP, satellite, etc.) and portable / palm computers.
• The best contact with potential clients is to be made personally (face to face)	• Interactive communications (Web-based video conferencing, etc.)
• You have to physically go through large amounts of information to find things.	• Automatic identification and tracking technologies and software (key word search, information filtering and sorting, etc)
• Periodic revisions need to be made	• Limited upgrades of high-performance computing and ICTs

7.2.1 Training and Education Issues

In many organisations, the single biggest expenditure is its payroll (in some cases as much as 60%). Therefore to invest in developing their most valuable resource (employees), who ultimately determine any organisations productivity and profitability, seems logical and essential (O'Donaghue 2001). Unlocking an individual employee’s potential creativity, skills, technical training, and ability to communicate effectively and timely, is believed to be the greatest opportunity for organisations to develop and improve long-term efficiencies. If untrained and unfairly treated, employees are less likely to perform to their full potential (Gupta and Thomas 2001; Linowes 1999; Swe and Kleiner 1998).With this in mind, it is essential to recognise the culture of an organisation and its effect on training.

Fortunately, the implementation, training and use of an ICT system will not fail as long as it ‘survives’ and continues to attract support in resources (Yeo 2002). With this support and commitment (from various industry stakeholders), organisations are able to carry out their projects (ideally with the view to serve the interest of those stakeholders). Yet, to ensure efficient and continued use of a new ICT system, trainers need (simultaneously) consider the possible negative effects associated with training potential end users. These include:

- fear and stress of employees (old and young) having to learn an unfamiliar / automated process; and

- impact on their self-esteem and ability to succeed (threatened confidence) (Vickers 1999).

7.2.2 Security Issues

A central concern industry organisations have in using the Internet, extranet, etc. for information transfer, is that of security (Smith and Scherer 1999). Interestingly, the industry's trust seems to be 'more biased' to telephone calls than to transferring documentation or information electronically (e.g.: email, Internet, etc.), yet (in basic terms) no more (or less) secure than the conventional telephone call – i.e.: email messages are routed between Internet service providers, over public telephone networks (Anumba and Ruikar 2002).

Information security (e-Security) is about protecting those assets. Therefore, information security and data protection complement each other (high-quality data protection implies high-quality information security), even though considered different – i.e.: data security is an important part of data protection, where as information security focuses on personal data. Yet, determining how to make data safe is only one aspect of e-Security. Equally important are ensuring the quality and accessibility of the data in relation to 'three information security model elements':

- **Confidentiality**: ensuring that information is available only to those who are authorised or entitled to see it;
- **Integrity**: ensuring that the information is accurate, complete and not corrupted; and
- **Availability**: ensuring that the information is accessible when required (Cabrera et al. 2001).

Interestingly, Australia (Queensland in particular) is identified as leaders in e-Security research and development capabilities, including:

- having the largest e-Security research community in the southern hemisphere;
- being the second largest cluster of e-Security companies in the world;
- supported by world class research infrastructure;
- having highly skilled e-Security workforce;
- having low operating costs, low taxes, low cost of living and low cost of conducting e-Security research;
- being in close proximity to Asia-Pacific markets
- having high availability of multilingual workforce; and
- being globally competitive (IIB 2002).

7.3 Project and Stakeholder Perspective

Failure, according to (Millet 1999) originates from: *not fulfilling a claim, promise, request, need, or expectation that arises in dealings between design and construction parties and the client*. Further identifying that only two to three of the following causes generate a failure between main stakeholders of a project – i.e.: senior management, project management, technical staff, clients and their agents:

- recommendations not followed by client or contractor;
- lack of disclosure (or understanding by client) of risks, uncertainties, and consequences;
- technical errors or omissions;
- accepting limited scope of work;
- inadequate documentation;
- lack of staff training; and
- breakdown of communication between senior management, technical staff, client, and contractor.

Industry members who do not clearly identify the critical elements of the implementation – be they technical or managerial; and don't identifying proactive, cost effective and preventive actions during a decision making process (e.g. whether or not to implement an ICT tool or system on a project) will increase the failure of that implementation (Millet 1999). (Yeo 2002) refers to the success or failure of developing and implementing ICT software systems as a function of managing the organisational; financial; technical; human; and political 'critical failure factors': These factors are grouped in two categories and can be viewed in Table 7-2.

Table 7-2: Critical ICT Factors

CRITICAL ICT FACTORS	
Failure (in the organisation and managerial context)	• hostile company culture; • improper reporting structure; • political pressure; • vested interest; • influences; and • inappropriate levels of management commitment.
Influencing (in the conduct of projects)	• pre-occupation with the technology in project planning; • technology focus over human relations; • poor consultation; • design by committee; • poor stakeholder management; • underestimation of complexity; • technical fix for a management problem; • poor competency levels of project management and project team members; and • poor selection decisions.

Interestingly, information 'overload' is considered a substantial drawback in the construction industry, caused (to a large extent) by information being 'pushed' onto other workers on a 'just-in-case-they-need-it' base. According to (Thorpe and Mead 2001) today's ICTs are said to hinder productivity, because each worker must spend time evaluating, responding or disposing each piece of information; and sort through piles of irrelevant information and data (in multiple of formats) to find one piece of information. Furthermore, traditional reporting systems are identified as just another communication barrier, where individuals or 'gatekeepers' restrict the free flow of project information by withholding information in order to gain a competitive advantage.

7.4 Government Perspective

Research indicates that 43% of Australian government organisations with access to the Internet (June 1998) reported 'security concerns' as a limitation to greater use of the Internet (Figure 7-1). Other limitations identified by government organisations included:

- 'technical difficulties' and 'costs' (both 40%);
- 'lack of skills or appropriate training' (33%); and
- 'not suited to the nature of the organisation' (4%).

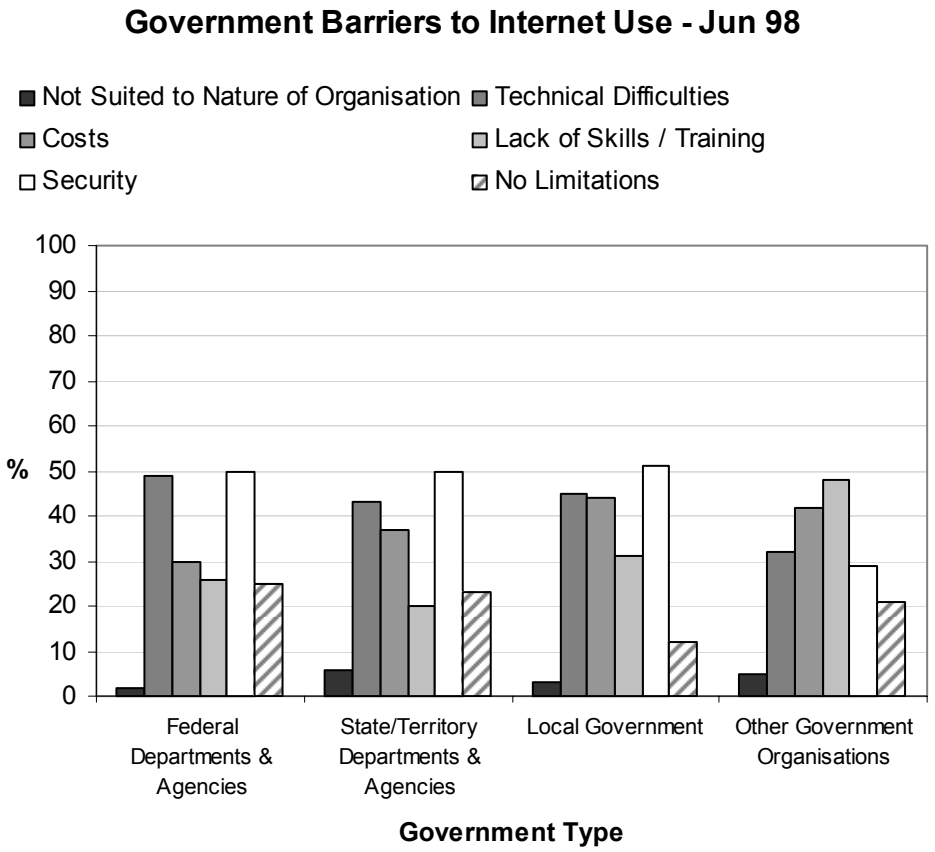
Only 19% of government organisations with Internet access identified 'no limitations'. Of government organisations with 1–99 employees:

- 39% reported 'lack of skills or appropriate training' as a barrier to greater use of the Internet;
- 37% reported 'costs';
- 31% reported 'technical difficulties'; and
- 27% reported 'security concerns'.

In contrast, for government organisations with 1000 or more employees:

- 76% reported 'security concerns' as a barrier to greater use;
- 66% reported 'technical difficulties';
- 45% reported 'costs'; and
- only 25% reported 'lack of skills or appropriate training' (ABS 1999).

Figure 7-1: Government Barriers to Internet Use



7.5 Summary

Implementation is the '*challenge that comes at the end of all new (and old) methods for improving organisations*', including: architecture development, change management, total quality management and new ICT systems (Revenaugh 1994). The construction industry is rapidly becoming a 'multidisciplinary, multinational and multibillion-dollar economy', involving large number of participants working together at dispersed locations whilst implementing various ICT technologies, becoming an information intensive industry (Rezgui et al. 1998).

It is predicted that higher quality (e.g. online) training and courseware will become standard methods of training. As a result, meeting the ever-broadening needs of industry learners and organisations and altering the industry's learning experience in future decades (Kilby 2001). With this in mind, ICT implementation teams and trainers may want to consider the following 'action points' to help accommodate this ICT adopting and learning industry:

- firstly, attempt to understand the organisation's culture and attitudes to training;
- recognise all levels of the organisation's culture in order to consider how positive attitudes can be fostered at all of these;
- determine measurable goals for changing attitudes to training in the organisation in relation to time;

- utilise (amongst other things) Table 5-1 to analyse the extent of the problem, the task to be undertaken, and how to bring about change;
- adopt a proactive approach to the advancement of organisational-level training and evaluation by ‘promoting’ this to senior management and by forging links with line managers and other key players in order to effect new organisational ‘beliefs’;
- choose a suitable change strategy or strategies to promote these new organisational beliefs;
- involve a wide range of organisational participants in the implementation stage of the attempt to change attitudes; and lastly
- actively evaluate the results of this ‘hands-on’ approach (Lewis and Thornhill 1994).

8 FUTURE INDUSTRY TRENDS AND RECOMMENDATIONS

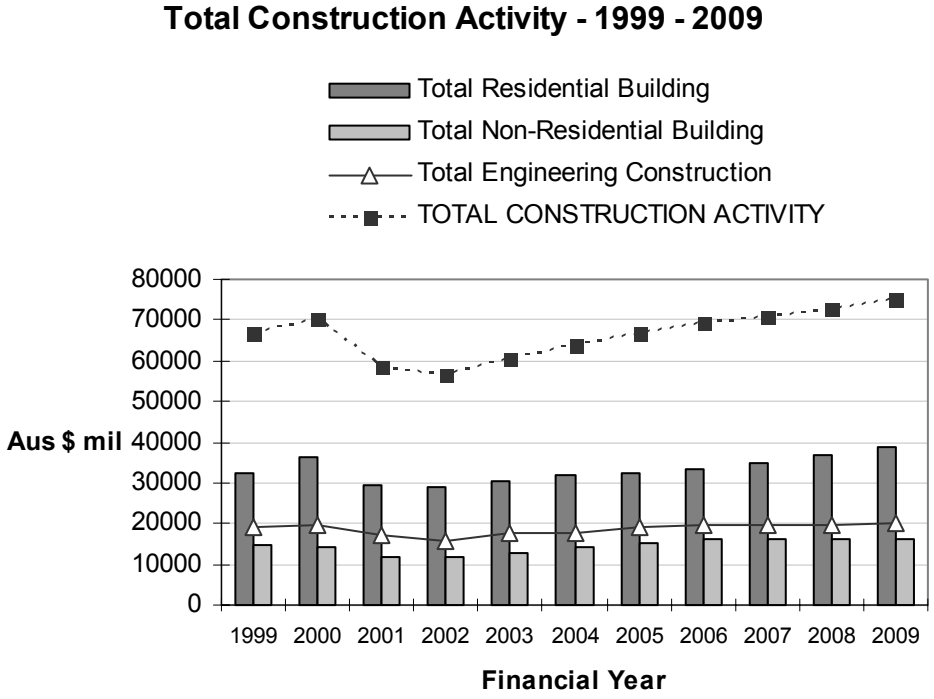
The construction industry has always excelled at managing complex programmes, often involving groups of people necessarily brought together for one-off projects and working in hazardous or inhospitable places. As a result, the industry has developed both flexibility and good skills in problem solving. What it is not so good at, however, is planning for the future (Foresight 2000).

8.1 Industry and Organisation Perspective

For sustained business growth, people in the construction industry need to plan. With projections of industry activity, industry organisations can make informed decisions and respond to future challenges. Industry people rarely have time to analyse (in depth) the economic, technological and social conditions, or the changes influencing the conditions in which their businesses operate. For this reason, they need easy access to information indicating future levels of industry activity and industry trends. By helping people understand the likely trends and levels of future activity within the main segments of the construction industry, businesses should be better equipped to anticipate future work in their areas of interest (APCC 2001).

The predictions in Figure 8-1 are designed to help people in all parts of the industry improve their business planning for 3 to 5 years into the future (1999 – 2009 financial years) – i.e.: when organisations are planning major investments and disposals (APCC 2001). Although the industry is described as 'cyclic', the underlying trend is still one of growth.

Figure 8-1: Total Construction Activity – Australia: 1999-2009



8.1.1 From Paper to Electronic

Project communications are becoming increasingly complex. Research has shown the 'rapid transmission' of effective project information and data is vital (key factor) to ensure project success and improved performance (Thorpe and Mead 2001; Olesen and Myers 1999). Current traditional information and communication flows within the construction industry are mostly manual and hence slow:

- Producing numerous paper copies of documents and drawings.
- Management of 'loose' documents is often time-consuming and tedious.
- Library 'archives' of documents need to be maintained to effectively access data as and when required.
- The reliance on third parties, such as courier services, can lead to delays.
- The added expense incurred in the delivery of project documents to project members who are geographically distributed (Anumba and Ruikar 2002).

Today, even the number of e-mails transmitted and received in organisations is rapidly approaching the number of printed (paper) letters sent and received daily where graphics and text is virtually identical to the printed (paper) mailing. The electronic version is transmitted at a fraction of the cost of a printed version; and delivered widely and almost instantaneously to any location in the world (Schelberg and Weinstein 1999).

However, to ensure the transition from paper to electronic is successful, the industry needs to 'crawl before it attempts to walk' the ICT road of technological change (Zipf 2000). The introduction of advanced innovative ICTs may allow the old (traditional) and new (ICT) practices to co-exist, at least for a short period of time, within any industry organisation, but will eventually lead to a more long-term reorientation of the organisation's structure, processes and culture (Palmer et al. 2001).

8.1.2 Interoperability

The recent growth in private e-Marketplaces operating within an industry sector raises the issue of interoperability between different electronic exchanges – i.e.: to ensure seamless business performance across sectors. Future development of open standards will be a vital component to interoperable electronic exchanges and in attracting supplier communities, especially small firms, to participate broadly in e-Commerce (APCC 2001). The International Alliance for Interoperability (IAI) (http://www.sgo.com.au/iai-ac/) and the continuous development of Industry Foundation Classes (IFCs) will greatly influence these developments.

8.1.3 e-Commerce

Due to the eCommerce technology changing at a rapid and ever increasing pace, any future trends are difficult to predict. Companies will have to devise new measures and strategies to automate their current business processes (influencing both cultural and technical aspects), and incorporate e-Commerce applications in their day-to-day business processes. Research has identified the following e-Commerce trends within the construction industry:

- **M-Commerce**: new research taken up to explore future opportunities in mobile electronic commerce (m-Commerce) based on today's ability to connect mobile devices - e.g.: mobile phones and Personal Digital Assistant (PDA).
- **Wireless communications (Bluetooth)**: with unlimited applications, such systems speed up the distribution of information and allow increased mobility - e.g.: remote located construction site personnel are able to communicate, collect and distribute data/information electronically.

- **Agent based procurement goods and services**: due to a 'shift' from 'software-as-tool' to 'software-as-assistant' where the user informs the software agent about various tasks to be performed and the software agent then acts on it in a proactive manner. These tasks include monitoring of incoming mail, comparing construction material price lists, or organising / distributing agendas when users are not present, etc (Anumba and Ruikar 2002).

Yet, when considering e-Commerce, it is important to keep in mind that significant efforts are involved in using technology to integrate trading relationships. It requires a commitment from business to work together on solutions that are technology 'neutral'. For e-commerce to be fully effective, emerging systems (such as m-Commerce) must integrate with established technologies - e.g.: the only e-Marketplaces that thrive in the future, will be those that integrate with a firm's existing 'back-end' systems. The main driver for e-Commerce to reach its full potential will be companies collaborating to develop whole-of-industry solutions and deliver shared benefits. To achieve this, companies will need to share their understanding of business information and workflow processes, and agree on how they can best automate their interchanges for efficiency. This will then free business resources to concentrate more on competitive issues such as product quality and price (APCC 2001).

Dramatic developments in the performance of ICTs, and the widespread 'explosion' of applications and future trends (based on these innovative technologies), are described as 'universally anticipated', and include (Simmonds and Clark 1999):

- Widespread use of simulation, including modelling and virtual reality, for more robust design and specification.
- Increased use of sensors and communications systems will reduce further the need for a worker at the point of process or manufacture, and for precise identification of faults.
- Robotics and computer-controlled automation will reduce further the need for people to perform dangerous or repetitive tasks.
- Rapid growth in at-a-distance transactions (B2B purchasing, electronic banking, Internet-based services and retailing, etc).
- Prompt growth in the volume of information and data available, both commercial data (eg flight schedules) and public records (eg government contracts on the web), will be allied with increased power (and precision) of search facilities.

Finally, the construction industry and its participants need to start realising that:

- e-Commerce is here to stay and that the 'open 'availability of essential information and data is important to facilitate on-line decision-making.
- Technology can bridge the traditional gap between design and production.
- Joined-up manufacturers, suppliers and off-site production can lead to greater resources for research and development into new products and processes.
- Industry standard models may enable automated information sharing across the entire value chain - from products to projects.
- It is essential for the construction industry to play an active part in setting the world standards that everyone will eventually need to use.
- Specialist contractors, suppliers, contractors and the design team will use web-based project portals to manage the project and its associated information.
- For an industry susceptible to adversarial approaches, the issue of trust in the supply chain will be critical.
- Greater operating effectiveness and supply-chain efficiency needs new skills and talent - attracted through better prospects and changed perceptions (Foresight 2000).

8.1.4 Training and Education

It is strongly recommended that construction organisations become learning organisations - attuned to absorbing and using knowledge and providing for lifelong learning. Investing in

human capital, to bridge the skills gap, in research and development, and knowledge awareness, will help to maintain competitiveness. Within the next ten to twenty years, the construction industry will require a complete range of different skills. To meet these needs, a 're-think' in the way construction education is organised to deliver these skills is required, due to computer and ICT integration of construction processes, implying a need for 'cross-disciplinary education' (Foresight 2000).

There is also a significant role for tertiary education to develop and support the understanding of how to evaluate and implement technological change and innovation. This provision is required both in undergraduate / postgraduate courses to create a more receptive and able cadre of construction professionals (including the creation of a more common understanding) as well as the role of providing specific research and consultancy support to companies or networks (CRISP 2000).

Benefits to be gained from investing in improving the skills and knowledge of employees include (Foresight 2000):

- highly trained and motivated workers leading to more successful firms;
- better training will raise industry standards and improve employment prospects;
- a healthier and happier workforce;
- an improved image for the industry and attraction of more skilled people;
- research and development has long-term economic gains;
- an innovative environment that will stimulate and create more and better ideas;
- more flexible use of multi-skilled people; and finally
- a high-tech image delivering improved social benefits will make the industry more attractive as a career for young people.

8.2 Project and Stakeholder Perspective

8.2.1 Improved ICT Implementation

Investigating the practical ('real life') issues of successfully integrating a new technology into the geographically dispersed Canadian health system, five 'key issues' for successful ICT implementation were identified. Although undertaken within the UK health sector, construction industry participants can channel any lessons learnt and recommendations provided by the above research, and apply them to current / future ICT implementation projects.

- **Readiness of the environment:** the more prepared the environment, the more likely successful implementation will occur – i.e.: upfront recognition of: workstation and ICT standards (professional and technical); training requirements; ICT champions and onsite coordinators; hardware and software planning; as well as human requirements.
- **Analysis, strategic business plans and diverse partnerships:** lessons learned and recorded experiences in academic literature need to be examined prior to implementation. Additionally, sustainability and accountability issues need to be included in a business case reflecting upon the need for any reengineering or reorienting of routines or processes. Finally, any public sector, private sector, research, academic and other industry organisation partnerships are to be recognised for the project.
- **Equipment and ICT vendors:** the purchasing (budget restriction) of compatible hardware, software and ICT equipment (standards, interoperability, interconnectivity, etc); renovating any space; and choosing appropriate vendors (providing maintenance, replacement, accountability and training) is described as one of the more challenging and important implementation issues.
- **Staged implementation:** a gradual / staged implementation is recommended.
- **Evaluation:** research identifies the lack of evidence and evaluation results upon which to make implementation decisions, as a major impediment. Suggesting the compilation of a

database on lessons learned (e.g.: reporting on ongoing evaluation at each stage of the implementation) and best practice recommendations, and sharing it with other industry members (Jennett and Andruchuk 2001).

Supporting the above recommendations and to help increase and strengthen the process of realising ICT adoption benefits, research recommends:

- **Increasing awareness of, and skills to implement IT–based strategic change by:**
  - developing and distributing case studies and best practice in moving from automation to strategic transformation in the construction industry;
  - developing and running short courses for SMEs on capturing the benefits of IT management innovations; and
  - developing and supporting a web-based 'help desk' on current best practice and available support.
- **Restructuring the industry supply chain to leverage IT benefits by:**
  - commissioning an international comparative study of the impact of regulatory frameworks and effective inter-organisational IT systems on industry structures; and
  - develop tender guidelines for Commonwealth and State Government projects that encourage IT-enabled collaboration across the supply chain.
- **Supporting the database-centred approach by:**
  - providing support for the development of project-centred shared databases; and
  - supporting the development of standards enabling inter-operability.
- **Encouraging a performance-based, value-added focus for IT use in the industry by:**
  - establishing industry-wide awards for IT best practice;
  - supporting industry forums on the advantages of using IT for value-added as apposed to cost-minimising IT strategies; and
  - researching the contribution of regulatory changes to the adoption of IT-based value added strategies by the industry (Fujitsu Centre 1998).

Furthermore, to increase the rate of ICT adoption within the construction industry, organisations are to consider the following 'actions':

- Increase external requirements: where customers mandate the use of specific technologies;
- Create 'problems': when measuring the performance of work processes – identify problem areas and initiate change. One strategy is by setting high performance goals or 'artificial problems' to initiate change;
- Increase potential for competitive advantage: where construction customers consider the contractors technological capabilities as a criterion in selection;
- Increase technological opportunities: dictated by the understanding of its benefits, availability of resources and organisational capabilities;
- Closer cooperation between technology developers and contractors: required to develop technologies that address the contractors operational needs; and
- Reduce the contractor's initial costs and costs of failure: by all project participants sharing the costs, risks, and benefits of new technologies (Mitropoulos and Tatum 2000).

Finally, the following directions are identified as being critical to the successful take up of ICT within the construction industry:

- Maximise access to shared learning across the construction industry whilst using knowledge from other industries;
- Require information from suppliers in electronic form;
- Expecting electronic procurement to be used in all phases of project procurement and facilities management;
- Using advanced tendering systems which provide real time accessible information to all interested parties (speedier interaction);
- Driving process re-engineering through structural changes in procurement processes of governments;
- Working with industry to integrate IT through the entire supply chain;

- Facilitate the use of ‘project Web sites’;
- Manage the use of ‘as-built’ information;
- Capturing and sharing information to better understand lifecycle costing;
- Adopt systems to share information in a usable form; and
- Resolve issues including: design copyright, intellectual property rights, confidentiality and commercial advantage (APCC 2000).

8.2.2 Security

Legislatures are identified as typically ‘lagging’ behind technical innovation and social change (Woulds 1997). The successful implementation of ICT tools and systems (especially Internet-based) within the industry, are susceptible to the current legal status regarding electronic transmissions, use of electronic signatures, etc. Commitment by both government and industry sectors is required to help develop more innovative strategies to build a stronger and more competitive construction industry. Current legal investigations, aimed at strengthening organisational and individual use of electronic communications on projects must continue, thereby providing better management of communication risks such as:

- **Authenticity**: This concerns the source of the communication - does it come from the apparent author?
- **Integrity**: Whether or not the communication received is the same as that sent - has it been altered either in transmission or in storage?
- **Confidentiality**: Controlling the disclosure of and access to the information contained in the communication.
- **Matters of evidence**: This concerns e-communications meeting current evidentiary requirements in a court of law, for example, a handwritten signature.
- **Matters of jurisdiction**: The electronic environment has no physical boundaries, unlike the physical or geographical boundaries of an individual state or country. This means that it may be uncertain which State’s or country’s laws will govern legal disputes about information placed on the Internet, or about commercial transactions made over the Internet (Electronic Transactions Act 2001).

8.2.3 Improved Innovation

The evaluation and decision-making process involved when adopting a new technology (ICT) within construction industry organisations is considered as being at the ‘core’ of the innovation process. With this in mind, the following actions are suggested for managers to help increase the rate of technological innovation and the likelihood of success:

- **Strategic Innovation:**
  - Strategic technology assessment:
    Senior executives must identify and continuously monitor the ‘core’ technologies for the company – i.e.: technologies that directly affect the company’s ability to compete and meet customer needs.
  - Thorough technological specification and evaluation:
    In order to address the risks and maximise implementation success – not by solving all potential problems, but by understanding the operational needs and capabilities that the new technology creates, its effects on other interdependent organisational systems, and by identifying the major areas of potential implementation problems.
  - Senior management direct involvement:
    Senior executives are to have direct participation in the formulation, specification and evaluation of the technology. This ‘informed intuition’ provides the necessary confidence to make an adoption decision.
  - Implementation strategies:
    Ensuring the implementation process focuses on maximising on the likelihood of success and minimises the consequences of failure.

- **Project Level Innovation:**
  - Provide more solutions: increased innovation by increased technological solutions, opportunities, and 'success stories made available to project personnel.
  - Provide implementation support from non-project budget: two positive effects will result from providing additional resources without burdening the project budget:
    - (a) shift the project managers focus from minimising cost and consequence of failure, to maximising the likelihood of success; and
    - (b) the company opens the door for technological implementation that may not be successful or 'pay off' on the first project. Any benefits should be tracked and lessons learned should be collected and disseminated for future implementations that are more successful.
  - **Technology Level Innovation:**
    Driven (primarily) by the four industry conditions in Section: 6.2, and by the organisational factors (sensitive to those conditions) (Mitropoulos and Tatum 2000).

8.2.4 Increased Competition

The current competitive drive of the industry is that firms adopt ICT as a 'necessity to drive costs down'. The gap between the current use and potential of the technology indicates that these competitive 'dynamics' will continue for the near future. The industry has the opportunity to alleviate some of these effects by successfully becoming a world leader through the use of ICT; and by learning how to transform its organisations, reconfigure the supply chain, and deliver new, improved and qualitatively different services and products (based on local and overseas market trends) (Fujitsu Centre 1998).

8.3 Summary

Due to the nature of the industry involving large numbers of geographically dispersed organisations and individuals, project communication activities are inevitably complex. Ongoing R and D efforts in determining ways to improve traditional (paper-based) methods of communicating, through the implementation and application of standard off the shelf ICT tools and systems within the construction industry, accentuates increased recognition of the potential opportunities and benefits these innovative technologies have to offer (Anumba and Ruikar 2002).

Research shows there is also a 'perceived fear' of 'exploitation' of technology-led innovations within the industry, and that industry practitioners are yet to be convinced of supportive terms and conditions of contract do not lead to exploitation. In an attempt to lesson and ultimately remove this fear of exploitation, the industry is to determine ways to:

- Create a common understanding that would enable the construction industry to take positive action.
- Provide appropriate and easily accessible information on risk evaluation and implementation.
- Provide both cultural and contractual changes to remove the constant fear of liability and the concern to assign blame to individuals and organisations - creating an environment that is receptive to ideas, challenges and opportunities.
- Investigate unsuccessful projects to provide lessons for the future.
- Lessen constraints imposed by regulations, codes and standards that tend to oppose novel solutions (CRISP 2000).

When it comes to researching and developing innovative technologies, the construction industry is said to be lagging when compared to other industries (Michel 1998). Yet, the level of ICT adoption by the Australian construction industry appears to be neither more nor less advanced than that of our international competitors. Still, current R and D efforts need to be

increased in order to manage ongoing industry implications and inevitability of ICT driven change (including its effect on organisational cultures) (Black and Edwards 2000).

Finally, if Australian organisations continue to explore the competitive ‘dynamics’ of the construction industry, without realising the current and future, trends and benefits of adopting innovative ICT solutions, it will limit their opportunity to internationalise (expand into overseas markets) and allow the continuation of international firms successfully entering local markets.

9 CONCLUSION

In this uncertain and ever changing world, the industry and its participants need to be creative, alert to opportunities, responsive to external stimulus, have a good grasp of the changing environment, and increase existing levels of confidence in its ability to adapt (Banks 1999). It is been over 40 years since the introduction of ICT tools and systems into the construction industry, yet organisations are still unable to obtain the many potential benefits of ICT investment - many years after the initial expenditures have been incurred. Furthermore, the industry has been identified as 'slow' in embracing innovative ICT tools and systems such as eCommerce, e-Conferencing, Internet and Intranets (Stewart et al. 2002).

The acquired knowledge about ICT (and other) cultures is proven to be a valuable aid to industry organisations, managers and other participants who are charged with making effective use of ICT. Furthermore, organisations need to be aware of the larger 'patterns of interpretation' (develop out of its ICT policies) – e.g.: middle managers may be convinced of implementing an innovative ICT system and realise its importance to business needs, but may be confronted with dissatisfaction and unresponsiveness from senior management. Research suggests that all industry organisations recognise the difficulty of implementing change due to the 'persistence of enduring values and assumptions that are deeply rooted in human experience'. Cultures cannot be 'designed'. Cultures overlap, producing tensions of opportunity for gradual cultural and technical change. Although unable to effect such changes directly, organisations (management) need to adjust / revise formal ICT policies by implementing stricter controls over 'user initiatives' rather than maintain dominant values (Kaarst-Brown and Robey 1999).

With regard to e-Commerce, it will underpin further growth in the Australian economy as it enables innovation and significant advances in productivity and efficiency within and across industry sectors. While the continued development of e-Commerce is still widely recognised as a major 'dynamic' in business, there are signs that a more realistic understanding is emerging of how it will act to transform business. The e-Commerce market has seen significant changes over the last two years, focusing on moving beyond the technology and towards how these tools can make business processes and relationships more efficient. The underlying principles of doing business are proving to be just as important in the information age. The implementation challenges of e-Commerce are also more widely recognised. There is increasing evidence that companies can realise the benefits of e-Commerce by collaborating to work on whole-of-industry solutions and standards (APCC 2001).

The pace of change will be fast and all embracing. It will create more and greater business opportunities than ever before, both at home and overseas. It will be highly dependent on information sharing, customer-centric thinking, electronic commerce and co-operation at every level throughout an integrated supply chain. It will also embrace a changed cultural thinking that impacts on and benefits numerous aspects of the user environment (Foresight 2000).

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11 GLOSSARY

For the purpose of this report, the following terminology definitions are used:

Table 11-1: Definitions

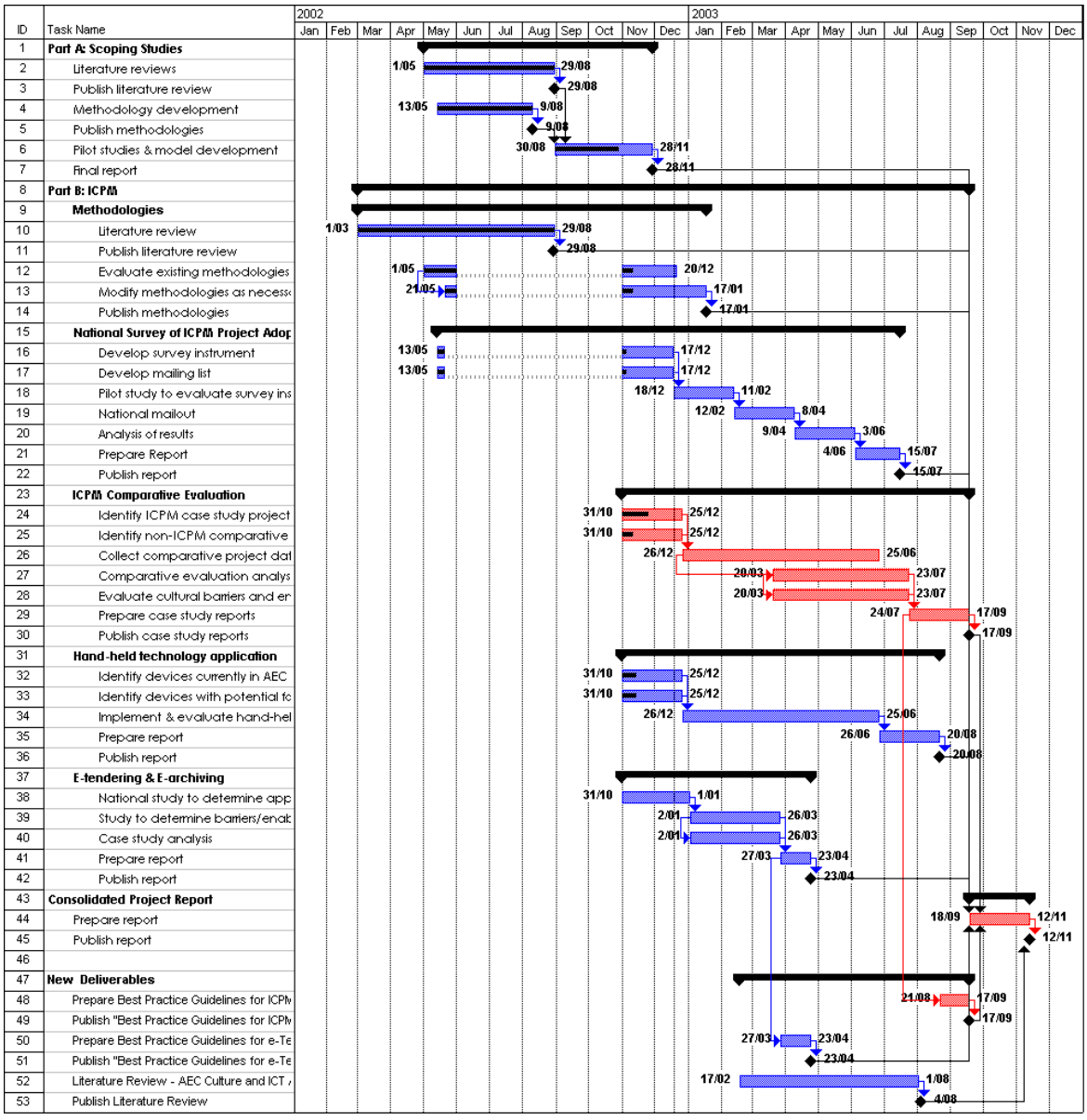
TERMINOLOGY	DEFINITION
Bluetooth	*Form of wireless technology that will remove the need for cables connecting computer equipment. It operates by means of low-cost short-range radio links that can be between mobile and stationary PCs, mobile phones and other peripheral devices* (Anumba and Ruikar 2002).
Construction Project	*Complex activity and team effort involving several participants (including client, architect, structural engineer, fabricator and engineer), as well as numerous inter-organisational activities and dialogue* (Anumba and Ruikar 2002).
Construction	*A process rather than an industry, with activities (including design, constructing, maintaining and adapting the built environment). Involving a multitude of organisations from a range of different industrial sectors, working together in temporary coalitions on project specific tasks (including design, engineering, supply and integration, erection and installation of a diverse array of materials, components and increasingly complex systems)* (Gann 1997).
Digital signatures	*Form of electronic signatures, based on 'public key' cryptography* (Ecommerce 2002).
ECommerce	*Can simply be defined as doing business by electronic means, typically over the Internet (Anumba and Ruikar 2002).*
Electronic mail (email)	*The exchange of computer-stored messages using telecommunication equipment. Although the body of messages are encoded in ASCII text, one can send non-text files, such as graphic images and sound files, as attachments in binary streams. Email was one of the first uses of the Internet and is still the most popular single use. Email can be exchanged between users of online services and people on local or wide area networks, other than the Internet. Email can be sent to lists of people and to individuals who have an interest in a subject (as long as they have asked or given their permission to put their names on the list)* (DCITA 1998).
Electronic Signatures	*Data in electronic form which are attached to (or logically associated with) other electronic data and which serves as a method of authentication - meeting the following requirements*: • *uniquely linked to the signatory;* • *capable of identifying the signature;* • *created using means that the signatory can maintain under his or her sole control; and* • *linked to the data to which it relates in such a manner that any subsequent change of the data is detectable. (Ecommerce 2002).*
Extranet	*A relatively new concept yet rapidly becoming one of the industry's more visible technologies of the future. Defined by* (Smith and Scherer 1999) as*: a dynamic wide area network that links several different organisations, with a means of sharing information.*
Information System (IS)	*A system that: collects, records, stores and arranges data in the form of information* (Claver et al. 2001).
Information Technology (IT)	*The technical component of an IS as it includes: hardware, databases, software networks and other resources suitable for information processing* (Claver et al. 2001).
Internet - 'the Net'	*Redundant network and path independent method of transmitting data - originally designed by the US Defence Department. Its original intent was to develop a network that would remain functional even in the event of nuclear war. Today, the Internet is a worldwide network of computers that facilitates data communication services such as remote login, file transfer, electronic mail, newsgroups and the World Wide Web* (DCITA 1998)
Interoperability	*The exchange of information between separate computer programs without the loss of content or meaning* (Yum and Drogemuller 2000)
Intranet	'*Organisational Internets*' or *the application of Internet Technologies (WWW) that link an organisation's computers thereby allowing them to share and access information from common server computers* (Schelberg and Weinstein 1999; Damsgaard and Scheepers1999).
Geographic	*A computer based system (that incorporates CAD functionality) for storing, integrating,*

Information Systems (GIS)	*analysing and displaying data with spatial reference to the earth* (Zipf 2000)
Organisational Culture	*A set of values, symbols and rituals shared by members of a specific firm (sub-cultures* (Lewis and Thornhill 1994)*), which describes the way things are done in an organisation in order to solve both internal management problems and those related to customers, suppliers and the environment* (Claver et al. 2001).
Process Re-engineering	*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* (Love 1996).
SME	*Small to Medium Enterprises:* • *micro enterprises (those which employ 1-3 people),* • *small enterprises (those which employ up to 20 people if in the services industries or up to 100 in manufacturing industry), and* • *medium enterprises (those which employ up to 500 people)* (DCITA 1998).
World Wide Web (the web or 'WWW')	*A global hypertext system that uses the Internet as its transport mechanism. In a hypertext system, one navigates by clicking hyperlinks, which can call up another document, a graphic image or a sound file. The links can be to files on the same computer, or on a computer on the other side of the world. The web was conceived in 1989 when Tim Berners-Lee proposed the development of a system that would enable scientists to browse each other's papers, to the European Particle Physics Laboratory (CERN) in Switzerland. The language and protocol he developed led to the World Wide Web known today* (DCITA 1998).

12 APPENDICES

Appendix I: 2001-008-C Project Schedule

Figure 12-1: 2001-008-C Project Schedule



ID	Task Name
1	**Part A: Scoping Studies**
2	Literature reviews
3	Publish literature review
4	Methodology development
5	Publish methodologies
6	Pilot studies & model development
7	Final report
8	**Part B: ICPM**
9	**Methodologies**
10	Literature review
11	Publish literature review
12	Evaluate existing methodologies
13	Modify methodologies as necess
14	Publish methodologies
15	**National Survey of ICPM Project Adop**
16	Develop survey instrument
17	Develop mailing list
18	Pilot study to evaluate survey ins
19	National mailout
20	Analysis of results
21	Prepare Report
22	Publish report
23	**ICPM Comparative Evaluation**
24	Identify ICPM case study project
25	Identify non-ICPM comparative
26	Collect comparative project dat
27	Comparative evaluation analys
28	Evaluate cultural barriers and er
29	Prepare case study reports
30	Publish case study reports
31	**Hand-held technology application**
32	Identify devices currently in AEC
33	Identify devices with potential fo
34	Implement & evaluate hand-hel
35	Prepare report
36	Publish report
37	**E-tendering & E-archiving**
38	National study to determine app
39	Study to determine barriers/enab
40	Case study analysis
41	Prepare report
42	Publish report
43	**Consolidated Project Report**
44	Prepare report
45	Publish report
46	
47	**New Deliverables**
48	Prepare Best Practice Guidelines for ICPM
49	Publish "Best Practice Guidelines for ICPM
50	Prepare Best Practice Guidelines for e-Te
51	Publish "Best Practice Guidelines for e-Te
52	Literature Review - AEC Culture and ICT /
53	Publish Literature Review

Appendix II: Australian Businesses Using Information Technologies and the Internet - By State (2001)

Table 12-1: State Results (2001)

(Refer Figure 2-4, Figure 2-5 and Figure 2-6)

AUSTRALIAN BUSINESSES USING INFORMATION TECHNOLOGIES AND THE INTERNET (2001)	
STATE	**RESULT**
1. **New South Wales**	• ISPs decreased by 16; • POPs decreased by 33; • access lines increased by 12,169; • subscribers increased by 132,000; and • data downloaded by subscribers increased by 11 million Mbs.
2. **Victoria**	• ISPs decreased by 4; • POPs increased by 6; • access lines decreased by 487; • subscribers increased by 21,000; and • data downloaded by subscribers increased by 5 million Mbs.
3. **Queensland**	• ISPs decreased by 14; • POPs decreased by 21, • access lines decreased by 9,313; • subscribers decreased by 36,000; and • data downloaded by subscribers decreased by 22 million Mbs.
4. **South Australia**	• ISPs decreased by 3; • POPs increased by 5; • access lines decreased by 555; • subscribers decreased by 12,000; and • data downloaded by subscribers decreased by 1 million Mbs.
5. **Western Australia**	• ISPs decreased by 7; • POPs decreased by 13; • access lines decreased by 594; • subscribers decreased by 16,000; and • data downloaded by subscribers decreased by 3 million Mbs.
6. **Northern Territory**	• ISPs decreased by 2; • POPs decreased by 2; • access lines decreased by 28; • subscribers increased by 4,000; and • data downloaded by subscribers remained constant at 9 million Mbs.
7. **Australia Capital Territory**	• ISPs decreased by 3; • POPs decreased by 5; • access lines increased by 1,215; • subscribers increased by 2,000; and • data downloaded by subscribers increased by 1 million Mbs.
8. **Tasmania**	• ISPs remained constant at 28; • POPs increased by 3; • access lines decreased by 305; • subscribers decreased by 2,000; and • data downloaded by subscribers increased by 7 million Mbs.

Appendix III: ABS Survey Comparisons

Table 12-2: Fourteen Key Countries across Twenty-Three Statistical Indicators (2002)

REF NO.	14 KEY COUNTRIES													
	AUS	FRA	GER	HK	IRE	ITA	NOR	NZ	SING	S. KOR	SWE	TAI	UK	US
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1	97	90	97	99	84	93	**100**	93	98	99	**100**	98	94	94
2	11	5	9	13	8	1	20	8	14	1	6	25	7	**29**
3	64	46	51	75	60	65	69	68	59	66	68	69	60	53
4	67	35	47	62	44	42	60	62	64	**70**	65	58	47	65
5	52	22	36	58	46	34	52	54	55	56	**58**	51	47	54
6	5	13	8	52	1	4	5	5	25	**87**	12	38	4	19
7	54	20	36	59	35	34	57	53	59	62	**65**	55	42	64
8	72	48	54	69	66	46	77	75	65	71	**82**	64	61	76
9	92	42	64	89	78	54	100	94	84	81	**107**	76	77	101
10	64	73	65	41	46	60	64	64	68	66	**78**	52	43	64
11*	**99**	91	89	97	96	89	95	96	97	95	95	98	91	97
12	**88**	63	74	79	74	73	75	82	75	73	80	77	77	
13	**100**	4	5	7	53	7	7	30	8	1	8	1	13	75
14	36	21	16	15	29	6	14	36	31	2	20	4	26	**49**
15	56	40	47		32	52	37	63		53	41		39	**100**
16	20	40	39		46	22	67	20		12	**100**		41	41
17*	19.5	21.4	25	31.1	13.4	17.5	16.4	21.6	23.4	**45**	17.5	21	19	30.3
18*	64	61	81	35	47	36	74	62	47	67	90	42	73	**103**
19	24	18	32	22	3	5	55		18	10	71	18	43	**100**
20	37	13	23	27	20	10	33		37	27	53	43	30	**100**
21	25	21	30	25	5	19	**32**	16	23	13	18	5	8	21
22	50.7	40.1	40.6		46.9	37.8	36.5	36.8	43.4	33.4	29.4	52.5	47.1	**57**
23	83	73	75	75	73	67	81	70	79	70	80	72	81	**87**
Total	1280	900.5	1044	1030	1006	874	1227	1109	1073	1161	1344	1020	1070	1480
Score	55.7	39.15	45.4	51.5	43.8	38	53.3	52.8	51.1	50.5	58.4	48.55	46.5	67.3
Rank	**3**	**13**	**11**	**6**	**12**	**14**	**4**	**5**	**7**	**8**	**2**	**9**	**10**	**1**

Note:

- *****: *Combined score*
- *Leading score (%) for each indicator in **bold** numbers.*

Key - Indicator Reference Numbers 1-23:

1. *%of households with a fixed telephone line*
2. *% of households with more than one telephone line*
3. *% of persons 16 years and over with use of a mobile phone*
4. *% of households which own / lease a PC*
5. *% of households online*
6. *Internet connection speeds*
7. *% of persons 2 years and over with Internet access via a home PC*
8. *% of persons 16 years and over with Internet access from any location*
9. *% of persons 16 years and over with Internet access at home or work*

10. *% of persons 16 years and over with Internet access using the Internet*
11. *% of persons 16 years and over with Internet access by gender*
12. *% of persons 16 years and over with Internet access by age group*
13. *Number of persons 16 years and over with Internet access per ISP*
14. *Number of secure servers / 100,000 persons 16 years and over with Internet access*
15. *Price of 40 hours of Internet use at peak times*
16. *Charges for a basket of national leased lines of 2 megabits per second*
17. *Average number of Internet sessions and hours online per month*
18. *% of persons 16 years and over purchasing online*
19. *B2C as a % of GDP*
20. *B2B as a % of GDP*
21. *Peak penetration of online government services*
22. *E-government rankings*
23. *E-business readiness rankings*

The following points to note when comparing the above international survey results:

1. The **reference periods** of the surveys differ, with the Australian survey period being 6 months later than the surveys of Canada, the Nordic countries and the UK.
2. The **Canadian** and Australian surveys have a slightly different scope. Canada excludes enterprises in the Agriculture and Construction industries. Australia excludes Agriculture, forestry and fishing and (private) Education. The two countries both exclude very small businesses from their surveys but use different exclusion criteria. Whilst Australia excludes almost all non-employing businesses, Canada includes non-employers but excludes all businesses with a gross business income under $150,000 or $250,000 depending on the industry. It is thought that the impact of scope differences will be small at the level at which statistics have been presented in this publication.
3. The Australian scope differs from the common scope of the **Nordic countries**. In the comparison shown in Chapter 5, Australian data have been amended to (reasonably) conform to the Nordic common scope. Adjustments made to Australian data are to exclude information in respect of the Mining, Electricity, gas and water and Construction industries and to exclude data for all businesses with fewer than 10 employees. Even with those adjustments, there are some scope differences remaining. However, an analysis of Australian data indicates that the net effect of these remaining differences is unlikely to be more than 1 or 2 percentage points.
4. The **UK** and Australian surveys also differ in scope. The UK survey excludes the Mining, Electricity, gas and water and Construction industries and does not survey firms with fewer than 10 employees. In addition, the UK treats the Finance sector differently to the Australian treatment. In the comparison presented in Chapter 5, Australian data have been adjusted to the same scope basis as the UK, with both datasets excluding the Finance sector.
5. The **income concept used in the Canadian** and Australian surveys differs slightly. Canada compares the value of gross Internet sales (of goods or services belonging to and sold by the reporting business) with total operating revenue. Australia compares the value of income resulting from Internet sales of goods or services with total income (excluding extraordinary items). These definitional differences are thought likely to have only a small impact on the comparative results.
6. The **UK income concept** is slightly different to that used in the Australian survey, being a proportion of Internet sales to total sales (rather than Internet income to total income per the Australian treatment). It is thought that this difference is likely to have only a small effect on the analysis (ABS 2002).

Appendix IV: Sample ICPM Web-sites / Portals

Buzzsaw's Buzzsaw.com site

Buzzsaw.com (http://www.buzzsaw.com) describes itself as "*the premier B2B marketplace and collaboration workspace for the global $3 trillion building design, construction and real estate management industry. With its easy-to-use tools and services, Buzzsaw.com helps building professionals including architects, engineers, underwriters, contractors, and facilities managers to work more efficiently at every stage of the design, construction and building management process. The largest and fastest-growing on-line resource for the construction industry, Buzzsaw.com provides a comprehensive set of Web-based project collaboration and bid management tools, news, resource directories and e-commerce services. Buzzsaw.com, Inc. is a privately held company based in San Francisco. It is backed by Morgan Stanley Dean Witter's Private Equity and Real Estate Private Equity Groups, Bank of America, Impact Ventures, Autodesk, Inc. and Crosspoint Venture Partners*".

ProjectPoint is the centralised project workspace on the Web for architects, engineers, and construction professionals, and is associated with Buzzsaw.com. It is an easy-to-use yet powerful tool with intuitive features designed to connect your project team. ProjectPoint is the smart way to enhance productivity, reduce costs and boost your bottom line. See Shockwave demo at http://www.buzzsaw.com/content/services/demo.asp

Buildon Technology's projectCentre site

"*Buildon Technology* [through their projectCentre portal provides] *a way of working, using the Internet to interact with other parties on a project as though they are all in the same location*". ProjectCentre (http://www.projectcentre.net) users must authenticate using a username and password to enter the site. On authentication, the user is presented with a 'To Do' list, which highlights any activities on the site that need to be brought to that person's attention. They then tick off the 'To Do' list items as they are completed. This not only helps ensure all matters are brought to the attention of relevant people, but also helps those people manage their time. A click on an item in your 'To Do' list takes you to the document in question. For example, it may display a Request for Information (RFI). To reply to that RFI you fill out a simple form, and then click 'submit'. This action not only replies to the question, but also sends a 'To Do' list notification to all the people nominated on the RFI, and updates the RFI register to show the progress of this matter.

Other forms of document exchange are managed in the same manner. This also includes the management of a document register, and the exchange of CAD drawings. Drawings can be listed in the drawing register enabling any party to quickly determine the current revision of any document, and then either view or download it. This feature saves an enormous amount of effort on any sized project, where keeping track of document revision and issue is often a full time job. It also produces a large cost saving in document reproduction and distribution, since electronic transmission is relatively inexpensive, even over large distances.

ProjectCentre modules include: To Do manager; Dropbox: drawing register and transmittals; General correspondence; Requests for information; Instructions; Approvals; Project Overview (public area); Full site search; Meeting manager; Project Library; Contact Manager; Online Help.

Cephren's ProjectNet® site

Cephren ProjectNet® (http://www.cephren.com/) is a "*fourth-generation*" service designed by AEC industry personnel for ease of use and unlimited scalability. It claims to be the AEC standard for on-line project management and collaboration; a secure on-line solution for all project team members to communicate, share documents and collaborate using a standard Web browser; and a secure document management solution that stores all project documents and all project communications. Documents are date- and time-stamped so that everyone on the project has current information, anytime, anywhere. ProjectNet® professes being "*a complete end-to-end project management system that incorporates all workflows associated with construction projects, from submittals to punch lists*". Since the merger of Blueline Online and eBricks.com (to form Cephren) in January 2000, the company has established itself in the market by providing value-added services to industry-leading firms such as The Bechtel Group, Fluor Daniel, Morrison Knudsen, Webcor Builders, Gensler, HOK, 3Com, Odebrecht, and BSW International (http://www.aecnewsroom.com/cgi-bin/getframeletter.cgi?http://www.aecnewsroom.com/html/2000/july/newsroom/CephrenForbes.htm).

Viecon's ProjectBank site

Viecon.com (http://www.viecon.com) "*is an integrated, comprehensive offering of tools and technology to help projects succeed, by licensing Bentley's tools on a per-user, per-project or per-month basis with Viecon Licensing*". Using Viecon Platforms, Viecon functionality can be deployed in an organisation and integrated with existing back office systems such as EDM, ERP or EIM applications. Viecon.com offers state-of-the-art project extranet resources, which allow users to:

- Store, Share, Synchronise and Secure Content - Documents; Models; Drawings (DGN, DWG, DXF, IGES, ACIS, SAT, CGM, GRD); Specifications; Photos; Animations; Renderings and Sound.
- Collaborate - On-line meetings and Application sharing.
- Communicate - Threaded discussions; Forms; and E-mail
- Manage - Everything has an activity log; Automatic version control; Project calendar and scheduling; Task management; Team directories; Full access control and SSL encryption
- Put a Project in its Proper Context - News; Weather; Maps; Services and Support
- Utilise Industry Links - Materials; Professional organisations and industry publications.

Bovis Lend Lease's ProjectWeb site

ProjectWeb (http://www.projectservices.qld.gov.au/default.asp?ID=43) is a Web-based project management system developed within Bovis Lend Lease and used for their customers (only).

Project Services eProject site

Project Services, a business unit of the Queensland State Government's Department of Public Works, possess a unique knowledge and understanding of the complexities of government and the special needs of clients, and are the largest management and building design consultancy practice in Queensland, with over 725 staff and a current capital works program totalling in excess of A$800 million. Offices are strategically located Statewide, servicing State, Federal and overseas markets, without losing sight of the individual. The eProject site (http://eproject.projectservices.qld.gov.au/) delivers timely, cost effective and quality Client projects by using Project Services unique Web based document management

and drawing version control systems for consultants and contractors. This link is accessible to people working on the delivery of current client projects.

Meridian's ProjectTalk.com site

ProjectTalk (http://www.projecttalk.com/) is an Internet community designed specifically for the Architectural, Engineering, and Construction (AEC) industry, and provides applications; eCommerce; and industry information benefits. The first set of applications available at ProjectTalk is the Prolog product line, the industry's leading software application for managing the construction process from design through construction, viz. Prolog WebSite (Collaboration Application for the Project Team), and Prolog Manager (Power Application for Project Managers). ProjectTalk allows one to host the project data remotely, in a hosted environment. This hosting service allows authorized users access to the projects, utilizing robust security features that include project, feature and field-level security. It also means that ProjectTalk is a true turnkey solution - since one does not have to host the project, no servers or administrators are needed, there is no installation involved, and overhead is kept to a bare minimum.

Furthermore, Prolog WebSite 6 is powerful Internet-based collaboration solution, with multi-project tools, bringing every player on the project team together in real time. A project team will eliminate typical communication problems by using Prolog WebSite's robust workflow process, and by sharing design drawings, jobsite photos, project schedules and over 400 reports — all through an Internet browser. Designed for both document and data management, Prolog WebSite offers an intuitive, easy-to-use interface for all project team members. The Prolog product line has also managed the procurement process of construction projects since January 1999, now enhanced to manage the process over the Internet (Ecommerce) (http://www.mps.com/).

IronSpire's JobSite™ system

JobSite (http://www.ironspire.com/) provides construction teams with a project-specific extranet through which remote team members can communicate and access up-to-date documents using mobile computing and communication devices. Whenever a document is changed, or a request-for-information is updated, JobSite alerts users affected by the change in real-time via email or pager. By centralising and providing instant access to requests-for-information, construction drawings, change orders, and other project data, JobSite drastically reduces time spent waiting for project clarifications and enables all the project team members to be working off the most current plans. In addition, JobSite's archive feature provides a searchable, well documented, day-by-day record of the entire project on a single compact disc.

Each JobSite extranet is accessible quickly and easily via login on the IronSpire website, enabling general contractors to take immediate advantage of the service without new investment, and without encountering incompatibility issues with their subcontractors. JobSite's web-browser interface requires minimal training and enables the different team members to log on and share project information from any device that has web access capability. The project manager can set up work rules and viewing/editing privileges for each user. JobSite then dynamically generates a unique view specific to the user's profile and need for information.

Additionally, IronSpire is currently partnering with a variety of technology companies to continue to deliver Web-based applications designed to reduce costs, improve organisation, and make construction projects of all sizes easier to manage.

Constructware's Constructw@re system

Constructw@re™ (http://www.constructware.com/) is the first enterprise-wide project management solution designed for the Internet. Designed mainly for general contractors, architects and owners, Constructw@re™ enables companies to manage ALL their projects throughout the entire lifecycle, from pre-bid to completion, saving time, reducing risk and maximising profitability. Constructw@re for the Subcontractor™ (formerly ADVANTAGE SUB) is the first Project Management software designed specifically for the Subcontractor. This PC based application is a network system allowing all project data to be stored in a central database. Now all documents, created, logged and sent in an automated way, save time and provide added efficiency.

Framework Technologies ActiveProject® system

Bringing the extended team together by traditional means (travel, fax, courier, e-mail, and normal mail) is too slow and costly to meet the demands of today's competitive marketplace. As such, working closely with its customers, Framework Technologies has identified and solved the three fundamental issues that prevent efficient communication and make successful partnering difficult to achieve. They are the lack of:

- Access - a single point of access to all project information, whether document-based or system-based, across multiple companies;
- Feedback - a simple way of resolving issues and driving accountability among project team members, and
- Insight - an effective way of identifying schedule-threatening issues.

ActiveProject (http://www.activeproject.com/) is a program management solution designed to meet these needs. It enables teams to leverage the Internet to find, present, discuss, review, track, and collaborate on project-related information in real time. Companies adopting ActiveProject will:

- Drive more timely and innovative program delivery,
- Enable their project teams to work more effectively across geographic and organisational boundaries,
- Build closer and more lasting relationships with their customers and partners, and
- Transform their organizations and supply chains into effective e-businesses.

Appendix V: Key Research Studies

As illustrated throughout this report, there are numerous examples of ICT and ICPM implementations as well as R and D activities within the Australian and international construction industry. Presented in the following sections are six studies of international ICT and ICPM adoptions and R and D activities within the industry.

Study 1: Technology – Enhanced Project Management

(Zipf 2000)

– **Research Objectives**

The engineering department of Port Authority of New York and New Jersey set out to determine ways to produce more work with fewer staff using electronic communication tools. ICTs identified included:

- local area networks (LANs);
- wide area networks (WANs);
- electronic communication;
- integrated project management systems;
- geographic information systems (GIS);
- electronic document management systems;
- enterprise wide database systems; and
- email.

The engineering department established a pilot project to store contract drawings and files electronically (storage, retrieval and transmission of contract documents), with three main goals:

- make documents available on a compact disk for easy distribution;
- create a project-oriented centralised CAD drawing storage system; and
- provide electronic storage of contract documents.

– **Findings and Recommendations**

As distance often separated project team members and organisations, and effective communication were considered important in improving the quality on any project, the above technologies were found to:

- increase the ability to ‘change direction’ at any stage of a project;
- make it possible for ‘timely’ information to be provided to project managers thereby ensuring effective management; and
- have to become part of any projects daily communication channels.

Yet, to realise the above, the engineering department had to deal with a variety of issues (Table 12-3).

Table 12-3: ICT Implementation Issues

ICT ISSUE	DESCRIBED
1. **Electronic signatures and contract drawings**	Realising that the electronic transmission of engineering documentation is increasingly becoming common in the industry, the electronic approval software was identified as being relatively new and the standards of reliability, security and usability have not yet been established and proven for these systems.
2. **Format of drawing distribution**	Portable documentation format (PDF) was identified as fast becoming the standard for publication and distribution of documents via CD-ROM and the Web, due to: • the ability to convert computer-aided designs, documents, images, etc into a single format; • downloading of free software for reading PDF via the Web; • the ability to read, print or plot PDF documents without modifying or changing file extensions; • all files being in one common format for distribution.

Furthermore, researchers suggest implementing an electronic document management system (EDMS) to handle the extensive storage and retrieval of engineering documentation and specifications, potentially providing a number of benefits, including:

- simplified PC-based tracking and maintenance of documents and specifications;
- the use of 'version control' to keep track of different versions;
- documents can be submitted electronically for review and final distribution;
- the ability to electronically file and record documents, drawings and specifications in a centralised location; and
- immediate access by staff.

Study 2: Online Remote Construction Management (ORCM)

(Kajewski et al. 2002)

– Research Objectives

The Online Remote Construction Management (ORCM) project - a collaborative research project funded and supported by a number of Australian (Queensland) industry, government and university based project partners - commenced in July 1999 aiming (in general) to identify, examine and evaluate certain ICT / ICPM communication solutions on four remote located building and civil construction projects over a two-year period. Research concentrated on (but not limited to) investigating:

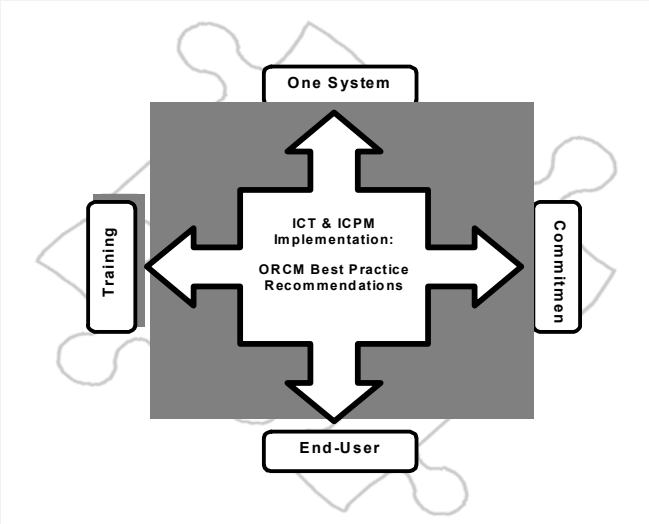
- perceived and actual communication practices of contractors with other project participants, using various ICT tools and the following two ICPM communication systems:
  - **ProjectCentre:** a "project web portal" or ICPM system for construction industry projects and team members to gain access to, or transmit project documents from any location where Internet services are provided. For more information on the projectCentre system, visit their web site http://www.projectcentre.net/.
  - **eProject:** similar (in concept) to projectCentre, this ICPM system was developed and implemented by a commercialised business unit of the Queensland Government Department of Public Works (Project Services). For more information on the eProject system, visit the following Web site: http://eproject.projectservices.qld.gov.au/.
- barriers that inhibit the flow of project related information; and
- the impacts, advantages, barriers, and challenges the implementation of an advanced ICT / ICPM solution has on a user and the communication flow process throughout a project.

– Findings and Recommendations

ORCM researchers, through implementing two ORCM surveys; formal and informal interviews; and undertaking extensive benchmarking and cost benefit analysis activities, identified a set of 'Best Practice Recommendations' that would help ensure successful ICT

tools and ICPM communication systems on geographically dispersed (remote) civil and building construction projects (Table 12-4).

Table 12-4: ORCM Best Practice Recommendations

ORCM 'BEST PRACTICE RECOMMENDATIONS'	
	
1 One System *(One Project – One Team – One System)*	• Project participants want to learn to use only one ICT tool or ICPM system for ease of understanding its capabilities, etc.
a. System Compatibility	• The capabilities and functionality have to be compatible with most other ICT products and ICPM systems used in the industry.
b. Ease of Data Entry	• Commonality of an ICPM system's access features and ease of data entry is most important.
c. Fully resourced Implementation	• Trialling an ICPM system (that has not had much exposure to industry participants) should be treated as a 'special case' with proper backing, support and experience from developers, implementers and researchers – 'buy-in' at the highest level possible.
2 End User – Prime Focus	• The end user is a key factor in gaining advantage from an ICPM system:
a. User v Quality and Accuracy	• The quality and accuracy of any project related communication or information (electronic or paper based) is directly dependant on the user or creator of that piece of information or correspondence (with or without an ICT tool) - technology alone is not enough to guarantee improved quality and accuracy of project related communications.
b. Trust	• Implementing a new ICT product or ICPM communication system must create a feeling of trust (reliability, relevance, need, etc.) for potential users.
c. Developed for the Construction Industry by the Construction Industry	• Whilst developing a new ICT product or ICPM system, the end users must be involved from the beginning to ensure a greater chance of successful ICT uptake.
3 Training	• Training in the use of a new ICPM system is essential. This includes continuous access to a telephonic or online 'Help Desk', regular onsite demonstrations and 'refresher' training sessions to ensure continuous learning and understanding of what the system is capable of, as well as recognising and accepting its limitations.
4 Commitment	• All project participants and stakeholders need to be fully committed to using the new ICT tool or ICPM communication system, with 'buy in' and collaboration at the highest level within participating companies, thereby reassuring and guaranteeing potential users of a 'corporate commitment'.
a. IT Driver	• Every project should have a 'driver' of ICT uptake (Superintendent or equivalent), encouraging, supporting and monitoring its application and its use throughout all phases of a project.
b. Legal	• ORCM 'Best Practice Recommendations' are susceptible to the current legal status regarding electronic transmissions, the use of electronic signatures, etc. Commitment by both government and industry sectors is required to help develop more innovative strategies to build a stronger and more competitive construction industry. ORCM Committee Members and their organisations have sought legal advice regarding the use of electronic communications on both public and private sector projects.

Study 3: Strategic Implementation of IT/IS Projects in Construction

(Stewart et al. 2002)

– **Research Objectives**

In order to facilitate ICT implementation and to encourage ICT uptake within construction organisations, researchers examine the implementation of a Project Management Information System (PMIS) on a case study project to electronically manage the supply and construction of a multi-million dollar telecommunications infrastructure project. Additionally, researchers further developed an earlier framework that developed by a South Korean research team looking at maximising the integrated utilisation of information systems throughout a project's lifecycle (Jung and Gibson 1999).

– **Findings and Recommendations**

As a result, researchers tested, trialled and evaluated the newly developed 'Strategic IT / IS Implementation Framework' based on critical assessment of market opportunities and threats, as well as organisational strengths and weaknesses. Researchers recommend the introduction of this proposed strategic IT / IS implementation framework to 'speed up' the rate at which changes in people, tasks and organisational structure will take place (Figure 12-2 and Table 12-5).

Figure 12-2: Strategic IT/IS Implementation Framework for Construction Organisations

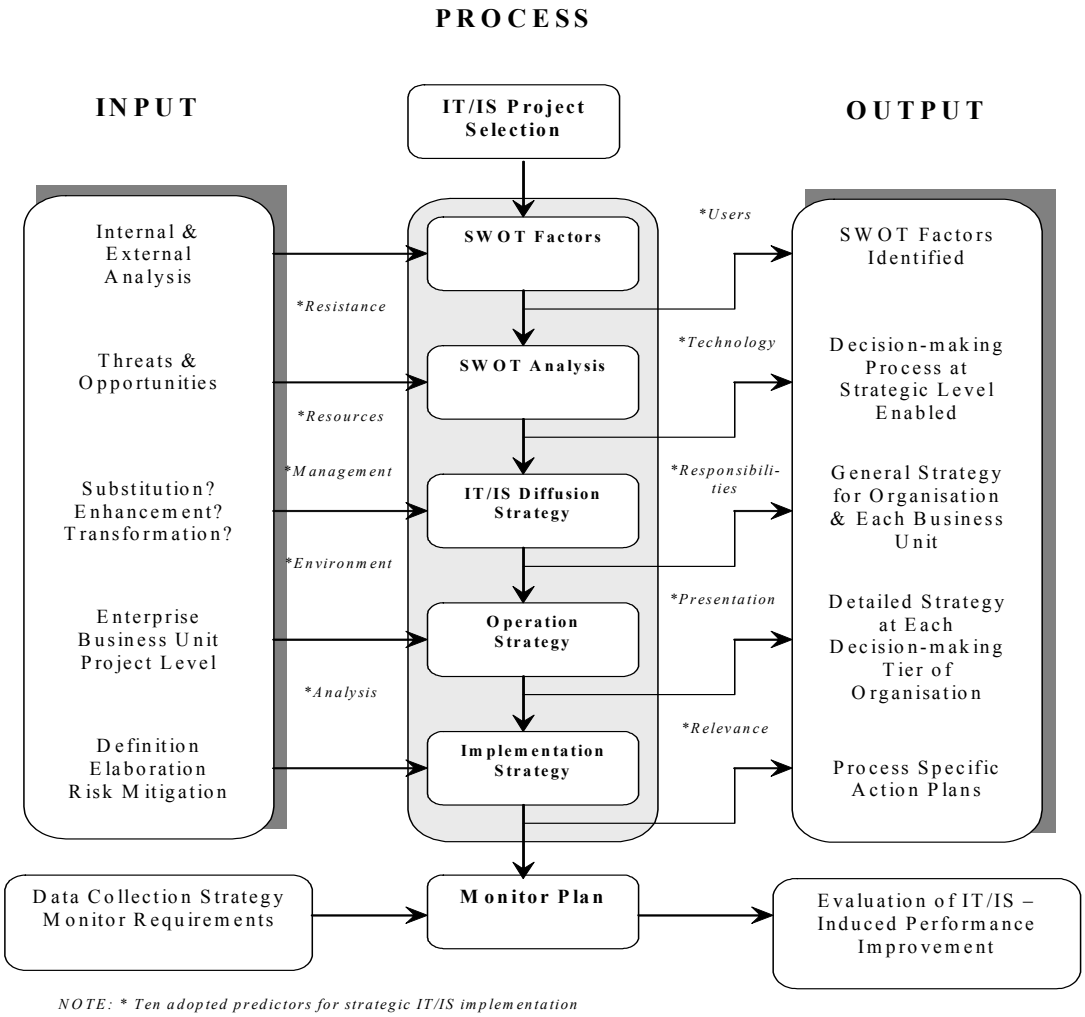


Table 12-5: Key to Figure 12-2

STRATEGIC IT/IS IMPLEMENTATION FRAMEWORK FOR CONSTRUCTION ORGANISATIONS	
STEP	**ACTION**
1 SWOT Factors	The strengths, weaknesses, opportunities and threats (SWOT) factors are identified by incorporating the values of the corporate management of the construction organisation (objectives, perceptions, beliefs, challenges, etc) whilst undertaking an internal (*environment in which the organisation is studying the potential opportunities and threats*) and external (*identifying the strengths and weaknesses of the organisation*) analysis.
2 SWOT Analysis	SWOT factors identified in step 1 form the bases of their analysis. Incorporating an analytical hierarchy process (AHP) within a SWOT framework proves to add value to the analysis – providing decision-makers with quantitative information by methodically and systematically evaluating the SWOT factors and their (current or anticipated) intensities.
3 IT / IS Diffusion Strategy	Based on the outcomes / recommendations of the SWOT analysis (reviewed by all that have a vested interest) the following needs to be determined to ensure efficient use of the proposed system: • how the proposed project (implementing IT / IS) will benefit the organisation ('tie-in' with existing strategies and plans); • how organisational assets and processes will be effected by the new IT / IS project; • what changes (replacement, improvement, transformation, etc) will need to take place in order to take full advantage of the IT / IS project's capabilities; and • change proposal recommendations (including the logic behind those) for the organisation's structure, people (culture) and their tasks.
4 Operational Strategy	Step 3 outcomes / proposals are developed in more detail by considering the decision-making levels of the construction organisation – i.e.: project, business unit and enterprise 'tiers' and analysed in terms of: • Functions (business systems); • Hierarchies and responsibilities (organisational structure); and • Technical architecture required (network, software and hardware, security requirements, etc).

5 Implementation Strategy	Expressed as the most detailed component of the proposed IT / IS implementation framework – examining the risks, strategic importance and coordinated integration within the evolution / development / transformation of the construction organisation, suggesting the following three stages:
	• Definition of clearly defined action plans – i.e.: activities including:
	  • inventory of actions for strategic IT / IS implementation;
	  • study of implementation procedures (budget and organisational constraints, types of finance, etc.); and
	  • action prioritisation (with reference to strategic importance).
	• Elaboration of action plan – i.e.: include:
	  • study of each action element (objectives, work breakdown structure, expected results, etc);
	  • time dimensions (constraints, precedence, etc);
	  • cost estimation (purchase, development, maintenance costs, etc);
	  • analysis of human resources (training, support, etc); and
	  • IT / IS management and coordination structure.
	• Risk mitigation and coping strategies: envisaged risk factors or identified weaknesses can be limited by developing a coping strategy (pre-determined actions).

6 Monitoring Plan	By simply developing an IT / IS strategic implementation plan will not guarantee a successful implementation. It is therefore suggested that careful consideration be given to the continual performance monitoring of the implementation throughout the lifecycle of the project.

Study 4: Project-Specific Web Sites: Friend or Foe?

(Thorpe and Mead 2001)

– Research Objectives

The industry's current information network is based on project or communication 'push' – i.e.: information moving successively to and from each member of the project team. Researchers suggests the implementation of alternative communication 'pull' technologies, where individuals access project information from a single central source – i.e.: project-specific Web sites (PSWS) giving construction personnel new ways of 'pulling' information needed by speeding up information flows to design and build today's complex and fast-moving projects. The difference between push and pull communication methods are shown in Table 12-6:

Table 12-6: Push v Pull Information Distribution

JUST-IN-CASE INFORMATION (PUSH)	JUST-IN-TIME INFORMATION (PULL)
Out-of-phase timing	In-phase timing
High volume	Low volume
Irrelevant data	User-selected data
Organisation focused	Project focused
Inconsistent formats	Common format (HTML)

– **Findings and Recommendations**

Findings suggest that the success of a PSWS is directly dependent upon the participation by key members of the project team – i.e.: key project players (including architect, project manager, superintendent and engineers) using the system on a regular basis. That while the Internet is undoubtedly here to stay, the speed and usability of project Web sites needs improvement before they will be fully embraces by the design and construction community. Regular participation can be enhanced through proper planning, training and promotion of a project technology champion.

Researchers further suggest that whilst the PSWS technologies are still in development, they show promise for improving and / or changing project communications. By 'pulling' project information from a Web-based system, project participants can evade traditional chains of command and eliminate many of the communication barriers inherent in 'push' delivery systems.

Study 5: Anticipating Reuse: Documenting Buildings for Operations using Web Technology

(Song et al. 2002)

– **Research Objectives**

Knowing that today's facility practices (involving architects, consultants, and facility operators from numerous other disciplines), produce information in a wide variety of formats, and due to the 'unpracticality' of having one unified structure for all this information (requiring agreement upon information / data format, contents and responsibilities), researchers adopted an 'integrated document management system' strategy that would utilises Web technologies to compose and compound documents based on the needs of specific users.

This 'just-in-time' (JIT) documentation process (based on information inputs, outputs, activities, resources and participants involved in the process) would potentially provide a practical solution among architecture, engineering, construction and facility management (AEC / FM) organisations. Researchers believe that by gathering various formats of data and converting them to a minimum and common denominator (machine readable and semi-structured formats), should allow more effective reuse of this building information (Table 12-7).

Table 12-7: Examples of Generic Formats

	DOCUMENT TYPES	REQUIRED FORMATS and STANDARDISATION
1	**Drawings**	• CAD format and Web-enabled format (d.g., DWG or DWF) • Sheet organisation standard (e.g. Uniform Drawing System) • Label names and equipment tags as provided by owner • Layer standard (e.g.: AIA CAD Layer Guidelines) • Embedded links on all scheduled items (e.g. mechanical equipment, .electrical equipment, control devices) • Use of symbols provided by owner
2	**Product and performance data,** (e.g.: schedules, test and balance reports)	• Spreadsheets or database with templates and fields provided by owner
3	**Equipment operation and maintenance manuals**	• HTML format and either Web or CD-ROM delivery PDF format - if HTML format is unavailable • Optical scanning if only paper based documents are available
4	**Design intents**	• XML documents type definitions and authoring tools
5	**Work processes**	• Documentation of processes through IDEFO, pseudo code or Web scripts

– Findings and Recommendations

Findings suggest implementing the JIT 'integrated document management system' prototype, whilst utilising Web technologies to compose and compound documents based on the needs of specific users, will not be successful unless people rethink and reorganise the existing building process throughout its lifecycle (Table 12-8):

Table 12-8: JIT 'Integrated Document Management System' Success Factors

	JIT 'INTEGRATED DOCUMENT MANAGEMENT SYSTEM' SUCCESS FACTORS
1	Collecting and storing information in the minimum required format in Table 12-7 may require additional responsibilities and expense.
2	The process of capturing design intention, and creating simplified drawings and diagrams depends upon resources of personnel and training.
3	Require agreements and consent among building owners and AEC / FM participants prior to implementation.
4	An information administrator's role is very important and needs to be redefined – i.e.: • Be actively involved in collecting and storing information in a certain format. • Analyse and create task templates. • Monitor and manage information uses, links and feedback for information update.

Researches further identified the following expected benefits from using the Web-based JIT 'documentation process prototype system', yet suggest continued investigations of similar innovative technologies (Table 12-9):

Table 12-9: JIT 'Integrated Document Management System' Advantages

	JIT 'INTEGRATED DOCUMENT MANAGEMENT SYSTEM' ADVANTAGES
1	Deliver necessary and concise information for operations: the system delivers: • necessary information - based on efficient operations task analysis results; and • concise information - on demand by incorporating diverse formats of information and filtering and customising information.
2	Easy access to related information: The web-based interface is a familiar and powerful way to locate and retrieve needed information.
3	Eliminate duplicated information and reduce re-creation time: the system reuses design and construction information, and eliminates duplicated information (saving time and resources) to create operations, maintenance and training documents.
4	Reduce training time and efforts: the system provides onsite and online JIT training information - enabling potential users to learn how to operate building systems and components.
5	Provide better update and reliability of information: the system provides an automatic workflow mechanism and redlining tool for updating and managing information efficiently.
6	Provide quality assurance of information: the prototype system monitors information usage and utilises this information for strategic information planning.

Study 6: Trying to Improve Communication and Collaboration with Information Technology

(Olesen and Myers 1999)

– **Research Objectives**

This research project - motivated by the desire to understand the relationship between the introduction of groupware, changes in work habits, and the organisational structure of an organisation - introduced an ICT groupware product (Lotus Notes TM) to facilitate communication and collaboration among the senior management team of a New Zealand tertiary educational institution. Although undertaken within the New Zealand educational sector, construction industry participants may channel any lessons learnt and recommendations provided and apply them to current / future ICT implementation projects.

To help realise their objectives, researchers adapted a previously developed five stage 'action research cycle' methodology that involved some form of collaboration between researcher(s) and practitioners to generate new knowledge useful for both research and practice (Figure 12-3).

Figure 12-3: Five Stage Action Research Cycle

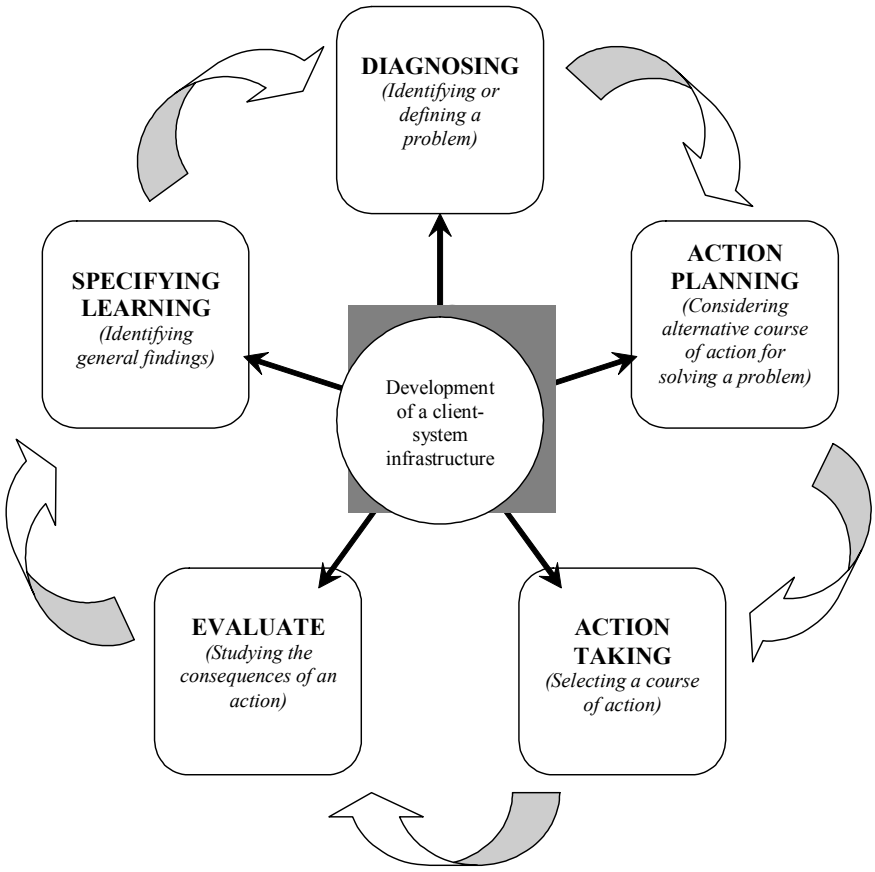


Table 12-10: Key to Figure 12-3

FIVE STAGE ACTION RESEARCH CYCLE	
PHASE	**ACTION**
1 Diagnosing	• Involves the identification of primary problems that are to be addressed within the host organisation.
2 Action Planning	• Specifies the organisational actions that should be taken to relieve or address these problems. These planned actions are guided by the theoretical framework of the action researcher.
3 Action Taking	• Implements the planned actions.
4 Evaluation	• Includes analysing whether the planned actions achieved their intended effects.
5 Specifying Learning	• Specifies what was learned during the action research project – i.e.: when the knowledge gained is applied within the organisation and communicated to the research community.

– Findings and Recommendations

Initial studies found that emerging technologies, such as groupware products and the Internet, offer the potential to 'dramatically improve' the way in which people communicate and collaborate in the organisation of the twenty-first century. The use of ICT to facilitate communication and collaboration has become an important theme in information systems research and practice.

Yet, contrary to previous research activities (often occurring in a 'laboratory' / isolated environment - usually suggesting positive effects from the use of groupware), this project found that dramatic improvements in communications and collaborative activities proved elusive (Table 12-11). Even though there was a real need for change, and senior management approved the project (on the basis that it would enable radical changes in coordination within the workgroup), researchers found that it was much more difficult to obtain these benefits in the 'social situations' of an organisation. Due to these 'institutional forces' which inhibit any dramatic change in work habits', it is imperative to understand the social environment (organisational culture) within which a new ICT system or product will be used (preferably prior to its implementation).

Table 12-11: Key Findings Using ICT to Facilitate Communication and Collaboration

USING ICT TO FACILITATE COMMUNICATION AND COLLABORATION	
FINDING	**DESCRIBED**
1 Use of 'action research' as a research method	• Researches found that whilst an action research project may not always be successful, its outcomes can still be useful as both researches and industry organisations can learn equally well from failure as from success: • In this case providing important insights into the culture and norms of the existing organisation.
2 Research results	• It is important not to underestimate the power of the 'counter forces' which maintain the 'status quo' – i.e.: *it is one thing to install an ICT groupware product, but quite another to transform existing norms and ways of working*. • These 'counter forces' can sometimes prevail despite the wishes of senior management (who in this case wanted to use ICT to challenge traditional organisational norms and ways of working). • The ICT groupware product initially 'worked' (used by all of the participants), but eventually existing (traditional) norms of communication and collaboration were reinforced.
3 Organisation Culture	• 'Changing and embedding a new culture within an organisation is perhaps the new challenge of the twenty-first century'.

13 AUTHOR BIOGRAPHIES

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Dr Kajewski is a senior lecturer with the School of Construction Management and Property at the Queensland University of Technology and is presently the A/Head of School of Construction Management and Property and the Course Coordinator for the Master of Project Management degree. Dr Kajewski is presently the Project Manager for a number of major research projects concerning the adoption and use of information and communication technology (ICT) being conducted in conjunction with the University, Government, and industry. The combined funded and in-kind value of these projects is exceeds A$1.2M and while all different, they are based around the aim of developing and demonstrating leadership in facilitating the use of online technologies for the design, management and construction of building and civil construction projects by identifying and implementing ICT solutions that will improve resource management; support and integrate total project life cycle considerations; increase efficiencies on projects, ultimately reducing overall cost; and improving project outcomes to project participants in the public and private sectors.

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Mr Weippert is presently undertaking a PhD to identify key cultural ‘drivers’ or ‘enablers’ of ICT uptake within ‘virtual’ building and civil project team environments. He is also a Research Assistant to Dr Stephen Kajewski (Project Leader) for the Cooperative Research Centre for Construction Innovation (CRCCI) research project 2001-008-C: ‘Project Team Integration - Communication, Coordination and Decision Support’. Prior to this appointment, he was Research Assistant to Dr Stephen Kajewski (Project Manager) on the Online Remote Construction Management (ORCM) research project. The ORCM project was a major research project undertaken by the Queensland University of Technology (QUT) and Commonwealth Scientific Industrial Research Organisation (CSIRO) Construction Research Alliance (CRA), based at QUT, Brisbane, Queensland, Australia.