Improving ICT Integration in Today's AEC Industry:
Recommendations & Guidelines

Report 2001-008-C-09

The research described in this report was carried out by:

Project Leader	Dr Stephen Kajewski (QUT)
Team Members	Paul Tilley, Mr John Crawford, Todd Remmers (CSIRO) Professor Swee-Eng Chen, Professor Dennis Lenard, Graham Brewer, Rod Gameson, Richard Kolomy, Rui Martins, Willy Sher (UN)
Researcher	Mr Achim Weippert (QUT)
Project Affiliates	Mr Geoff Caldwell (QDMR), Mr Mark Haug (QDPW)

Research Program C:
Delivery and Management of Built Assets

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

CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

The Cooperative Research Centre (CRC) for Construction Innovation 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 various research aims and objectives of the 2001-008-C (Part B) QUT / Industry Partner agreements, and as a major deliverable for the project, this report is not intended as a comprehensive statement of Architectural, Engineering and Contractor (AEC) industry best practice recommendations. Rather it should read as a set of research and industry recommended guidelines, based on extensive literature reviews and two years worth of investigative activities examining both public and private industry uptake of innovative information and communication technology (ICT) solutions, whilst highlighting the overall need for culture change.

EXECUTIVE SUMMARY

Supporting the research aims and objectives, and as a major deliverable for the 2001-008-C (Part B) project, this report provides a summary of research activities and outcomes from the following 2001-008-C (Part B) reports:

- **2001-008-C-02** – 'A Brief Synopsis in the Use of ICT and ICPM in the Construction Industry' (Kajewski S.L. and Weippert A. 2003)
- **2001-008-C-05** – 'Industry Culture: A Need for Change' (Kajewski S.L. and Weippert A. 2003)
- **2001-008-C-06** – 'Hand-Held Technology Review' (Kajewski S.L., Tilley P.A. et al. 2003)
- **2001-008-C-07** – 'Electronic Tendering: An Industry Perspective' (Kajewski S.L., Weippert A. et al. 2003)

Research Objectives:

The objective of this research project is to develop ICT (Information and Communication Technology) research and industry recommended guidelines to benefit the Architectural, Engineering and Contractor (AEC) industry, in relation to:

- improving implementation and application of an eTender system;
- improving use of innovative hand held technology solutions; and
- promoting a culture change philosophy.

These research and industry recommended guidelines are outcomes of an extensive research investigation, which involved:

- Identifying innovative ICT tools and Web-based communication tools and systems,
- Identifying ways to overcome AEC industry specific cultural 'barriers' and 'modifying' traditional work 'habits'; and
- Identifying improved implementation procedures and application opportunities within the public and private industry sectors.

Research Findings:

(a) Recommended e-Tender Guidelines:

In an attempt to ascertain any barriers and enablers from both a technological and end-user perspective, one of the main objectives of the 2001-008-C (Part B) research project is to undertake an extensive 'general' industry wide literature review on construction industry and Government current state-of-play pertaining to e-Tendering. From this investigation, researchers identified a number of eTender recommended guidelines (Appendix II) – i.e.: in relation to:

- The basic features, functionality and capabilities of an eTender system
- Risks industry professionals should consider when choosing an e-Tender process or system
- Improved Training & Education
- Improved Implementation
- Legal Issues

(b) Recommended Hand-held technology guidelines:

In order to help the Construction Industry utilise the many benefits on offer using hand-held technologies, Appendix V provides information to help guide industry stakeholders in the selection of suitable hand-held devices for use on construction industry projects - i.e.: in relation to:

- Selecting suitable handheld devices

- Construction activities / tasks suited to handheld devices
- Overcoming emerging technology limitations
- Future applications

(c) Culture Change Guidelines:

In an attempt to demonstrate leadership in implementing a cultural or technological driven change within the AEC industry, researchers identified 24 'general' industry 'Culture Change Guidelines' (Appendix VI) – i.e.: in relation to:

- Harmonising Attitudes, Values and Behaviours
- Understanding the 'Role' of Culture
- Identifying the Need for Change
- Motivating People
- Identifying a suitable Change Strategy
- 'Aligning' technology with people
- etc

Implications for industry and community:

The construction industry is categorised as being an information-intensive industry, where efficient information processing is continuously being challenged by the extreme fragmentation of the industry's demand and supply chain. New ICT technologies can help improve information and communication including:

- Reduction of numerous paper copies of documents and drawings
- Better document management and archiving
- Faster, cheaper and more accurate communication flows

The research and industry recommended guidelines highlighted in this report would help modify traditional work habits and improve current technical limitations; and encourage the use of innovative ICT and Internet-based solutions. This will help increase the overall knowledge, awareness and skills, of all industry stakeholders and encourage better integration of the construction industry.

Further research:

Leveraging off this and other internationally recognised research project outcomes, the main aims and objectives of an ongoing PhD research investigation intends to further identify, process, analyse and categorise the "raw" findings of these projects, and incorporate them into developing an innovative building and civil construction industry specific best practice ICT Culture Change Framework that will:

- provide project specific guidelines, customised models and step by step actions (based on an extensive literature review and by examining of a number of successful case study projects) to help project team members (contractor, consultant, client, etc) identify, assess, and finally overcome (via an 'actions list') any individual or organisational cultural barriers during the implementation of a technological driven change.
- provide a quick and easy method for building and civil construction industry project team members to assess their current levels of ICT adoption capabilities (eg "are we ready?" factor) and then support them in transforming themselves from a "business-as-usual" team into an "exceptional ICT adaptable" team.

1 INTRODUCTION

The construction industry is categorised as being an information-intensive industry and described as one of the most important industries in any developed country, facing a period of rapid and unparalleled change (Industry Science Resources 1999) (Love P.E.D., Tucker S.N. et al. 1996). Efficient information processing is continuously being challenged by the extreme fragmentation of the industry's demand and supply chain - that is, construction work being undertaken by a wide variety of organisations, utilising many different skill sets, processes, and technologies; whilst enduring low profit margins and fierce competition (Pietroforte R. 2003). 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 C.J. and Ruikar K. 2002).

Project communications are becoming increasingly complex, with a growing need and fundamental drive to collaborate electronically at project level and beyond (Olesen K. and Myers M.D. 1999; Thorpe T. and Mead S. 2001; CITE 2003). International predictions, relating to the amount of business conducted electronically have reached hundreds of billions of dollars, with little doubt that the emergence of the Internet is 'revolutionising' business access to communication and information. Web-based business activities within Australia, for example, are envisaged to increase significantly throughout the decade (NSW Government 2001; Anumba C.J. and Ruikar K. 2002). These 'e-activities' can generally be described as being about eliminating inefficiencies in traditional processes, communications, etc. and finding 'smarter' ways of undertaking these activities in an electronic environment, and generally requires industry organisational commitment, change and investment (NSW Government 2002).

Unfortunately, there still exists within today's construction industry a considerable lack of knowledge and awareness about innovative information and communication technology (ICT) and web-based communication processes, systems and solutions, which may prove beneficial in the procurement, delivery and life cycle of projects (NSW Government 1998; Kajewski S. and Weippert A. 2000). Consequently, through increased knowledge, awareness and successful implementation of innovative systems and processes raises great expectations regarding their contribution towards 'stimulating' the globalisation of electronic procurement activities, and improving overall business and project performances throughout the construction industry sectors and overall marketplace (NSW Government 2002; Harty C. 2003; Murray M. 2003; Pietroforte R. 2003).

Furthermore, over the past decade, the word 'culture' has dominated the thinking of many managers and become an integral part of their everyday language. In other words, today's global competitive business environment has made the culture of an organisation a critical aspect of its success (Sadri G. and Lees B. 2001). Yet, despite the growing awareness of various cultural issues, little attention is paid to the practical, day-to-day process involved in creating, managing and changing culture (Williams A., Dobson P. et al. 1993). Research indicates one of the last available 'mechanisms' left for organisations to improve their competitive position within the construction industry is by considering its people (culture) along with its technology. In other words, if one wants to make construction industry organisations, groups and project teams more efficient and effective, then one must better understand the role that culture plays within them (Schein E. H. 1997). 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 M. and Heraty N. 1995). Current 'secretive' organisational cultures, for example, who see information as a source of power, influence, and importance, and made available only on a 'need-to-know' basis, are to 'transform' themselves into more 'open cultures' where, whilst a degree of control is maintained, there is an atmosphere of mutual trust and respect within and between organisations (Baines A. 1998). Unfortunately, this transformation of personalities (culture) and traditional processes is not easy (Michel H.L. 1998), characteristically hindered by the industry's unique and determined way of 'doing things' the way it always has, and by its deeply embedded and resistive nature to change.

As a major deliverable for project 2001-008-C (Part B), this report provides a set of research and industry recommended guidelines, based on extensive literature reviews and two years worth of investigative activities examining both public and private industry uptake of innovative Information Communication and Technology (ICT) solutions, whilst highlighting the overall need for culture change.

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

2.1 Background

Four decades of international construction industry reports reinforce poor communication, information transmission; coordination; and teamwork issues are the cause of countless performance problems in the construction industry. Failure to achieve significant improvements in what are well-identified issues can be linked to the hitherto limited capacity to conceptualise and manage the very complex dynamics in project processes throughout the project's life cycle.

Debatably, today's industries, businesses and personal worlds are dominated by a wide range of technologies and e-activities, including: computers, email, Internet, Web sites, etc., finding it more and more difficult to function without them. Yet, the success of any profession is described as going beyond simply exchanging electronic information. Successful implementation of information and communication technology (ICT) and innovative web-based e-solutions requires careful consideration to meet industry needs. Where future research and developments (R&D) in determining new and improved ways of doing business through the Internet is dependent on the innovation of the industry (and end user), not only the technology itself – that is, matching technological innovation with the perceived needs and preparedness for change on the part of the industry.

Consequently, there is an urgent 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. By focusing on the potential of ICT and innovative web-based e-solutions, to better integrate project team members and the construction industry in general.

2.2 Aims and Objectives

The main objectives of the 2001-008-C (Part B) research project undertaking, is to:

- Demonstrate leadership in facilitating the use of innovative technologies for the design, management and construction of building and civil construction projects – potentially resulting in increased ICT knowledge, awareness and skills of companies in both the public and private sector.
- Identify appropriate hand-held technologies/applications 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 construction industry and Government current state-of-play concerning e-Tendering and ascertain the barriers and enablers from both a technological and end-user perspective.
- Identify, examine and better understand the 'deeply embedded' culture of today's AEC industry, its organisations, teams and participants - by focusing on human and cultural factors, limitations, barriers, and drivers as they arise from this investigation.
- Develop a set of research and industry recommended guidelines that will foster the expansion of an ICT adaptive culture - thereby stimulating stakeholder efficiencies and

encouraging the wider adoption of innovative ICTs in the building and civil construction sectors.

To help realise the above project aims and objectives, the 2001-008-C (Part B) project schedule provides a breakdown of projected research activities, deliverables, milestones, and allocated timeframes (Appendix I).

2.3 Research and Industry Recommended Guidelines Report

Supporting the above 2001-008-C (Part B) research aims and objectives, and as a major deliverable for the project, the 'Research and Industry Recommended Guidelines – Improved ICT Integration' Report provides a set of recommended guidelines to:

- help ensure improved implementation and application of an eTender system within the AEC industry;
- help justify increased uptake of innovative hand held technology solutions within the AEC industry; and
- promote a culture change philosophy within the AEC industry.

3 E-TENDER GUIDELINES

The eTender recommended guidelines (Appendix II: Tables 10-12) are derived from **Report 2001-008-C-07** – 'Electronic Tendering: An Industry Perspective' (Kajewski S.L., Weippert A. et al. 2003).

3.1 Introduction

The Internet has debatably revolutionised the way in which information is stored, exchanged and viewed, opening new avenues for business, which only a decade ago were deemed almost inconceivable (DCITA 1998; IIB 2002). Research indicates that even with a reserved uptake, the construction industry and its participating organisations are making concerted efforts (fortunately with positive results) in taking up innovative forms of doing business via the internet, including e-Tendering (making it possible to manage the entire tender letting process electronically and online) (Anumba C.J. and Ruikar K. 2002; ITCBP 2003). Furthermore, Government (often a key client within the construction industry),and with its increased tendency to transact its business electronically, undoubtedly has an effect on how various private industry consultants, contractors, suppliers, etc. do business (Murray M. 2003) – by offering a wide range of (current and anticipated) e-facilities / services, including e-Tendering (Ecommerce 2002).

Overall, doing business electronically is found to have a profound impact on the way today's construction businesses operate - streamlining existing processes, with the growth in innovative tools, such as e-Tender, offering the construction industry new responsibilities and opportunities for all parties involved (ITCBP 2003). It is therefore important that these opportunities should be accessible to as many construction industry businesses as possible (The Construction Confederation 2001).

Historically, there is a considerable exchange of information between various parties during a tendering process, where accuracy and efficiency of documentation is critical. Traditionally this process is either paper-based (involving large volumes of supporting tender documentation), or via a number of stand-alone, non-compatible computer systems, usually costly to both the client and contractor. As such, having a standard electronic exchange format that allows all parties involved in an electronic tender process to access one system only via the Internet, saves both time and money, eliminates transcription errors and increases speed of bid analysis (The Construction Confederation 2001).

3.2 eTender Literature Investigation

In an attempt to ascertain any barriers and enablers from both a technological and end-user perspective, one of the main objectives of the 2001-008-C (Part B) research project is to undertake an extensive 'general' industry wide literature review on construction industry and Government current state-of-play pertaining to e-Tendering. From this investigation, researchers identified a number of eTender recommended guidelines (Appendix II: Table 10).

3.2.1 Features

e-Tendering, in its simplest form, is described as the electronic publishing, communicating, accessing, receiving and submitting of all tender related information and documentation via the internet, thereby replacing the traditional paper-based tender processes, and achieving a more efficient and effective business process for all parties involved (NT Governement 2000; NT Government 2000; NSW Department of Commerce 2003; NSW Government 2003). Although most of the e-Tender websites investigated at the time, maintain their tendering processes and capabilities are 'electronic', research shows these 'eTendering' systems vary from being reasonably advanced to more 'basic' electronic tender notification and archiving services for various industry sectors.

Research identified a number of e-Tender system recommendations pertaining to its basic features, functionality and capabilities:

- Distribute all tender documentation via a secure web-based tender system – thereby avoiding the need for collating paperwork and couriers.
- The client/purchaser should be able to upload a notice and/or invitation to tender onto the system.
- Notifications are sent out electronically (usually via email) for suppliers to download the information and return their responses electronically (online).
- Updates and queries are exchanged through the same e-Tender system during the tender period,
- The client/purchaser should only be able to access the tenders after the deadline has passed.
- Hold all tender related information in a central database, which should be easily searchable and fully audited, with all activities recorded.
- It is essential that no tender documents can be read or submitted by unauthorised parties.
- Users of the e-Tender system are to be properly identified and registered via controlled access. In simple terms, security has to be as good as if not better than a manual tender process. Data is to be encrypted and users authenticated by means such as digital signatures, electronic certificates or smartcards.
- Assure all parties that no 'undetected' alterations can be made to any tender.
- The tenderer should be able to amend the bid right up to the deadline – whilst the client/purchaser cannot obtain access until the submission deadline has passed.
- The e-Tender system may also include features such as a database of service providers with spreadsheet-based pricing schedules, which can make it easier for a potential tenderer to electronically prepare and analyse a tender.

3.2.2 Risk

When it comes to industry professionals choosing electronic communications via an e-Tender process or system, the potential legal risks in using such a system or process are directly proportional to the increasing levels of electronic interaction. Three e-Tender risk categories have been identified during this investigation, namely:

- **Category 1:** Where tender information is posted on the internet as 'pure information'.

Recommendation

Although exposed to minimum levels of risk, attention must be given to its contents – that is, truth, accuracy, not misleading or defamatory, etc.

- **Category 2:** Where the e-Tender web site claims to have tender related information that tenderers need to rely on and perhaps download.

Recommendation

In this case, owners or managers of the e-Tender system are to spend more time ensuring that what is on their site is complete, accurate and true. The inclusion of a 'non-reliance' exclusion clause may also be necessary. Ensure the tender documentation can in fact be successfully downloaded (in its entirety), especially if tenderers are asked to reply in hard copy format.

- **Category 3:** This is at the top end of the 'risk scale', having a fully interactive internet-based e-Tender system, where tenderers both receive an invitation to tender, and reply with a tender bid electronically – that is, with no option of obtaining a paper copy of the tender documentation (except by printing out the contents of the web site).

Recommendation

In this case, security of information and integrity of the e-Tender system is of paramount importance. Here, legally binding and enforceable contracts are being formed electronically, leaving little room for error in receiving, sending, or storing the information. Furthermore, as owners or managers of the e-Tender system, they are unable to simply exclude all liability for what could happen during an electronic e-Tender process, and will likely have to assume some of the unforeseen risks (especially when an electronic reply is the only option) (Worthington R. C. 2002).

3.2.3 Training and Education

Whilst this report is written in 'plain English' and without the use of too many technical terms and phrases, many have become 'buzz-words' in certain industry circles over the past decade (The Construction Confederation 2001). The term e-Tendering, for example, is one of many technical jargons that could act as a deterrent for many when given the opportunity to adopt an electronic tender process, simply due to lack of understanding or misconception.

In an attempt to help increase today's construction industry participant's uptake of innovative technologies, systems and processes (such as e-Tendering), it is strongly recommended that construction organisations become learning organisations. Due to the increasing 'electronic integration' of construction processes, industry participants have no choice but to acquire themselves a complete range of new skill sets, and to 're-think' the way current construction education is organised in delivering these skills, thereby 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 accept, 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) (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.

3.2.4 Implementation

When it comes to the implementation of an e-Tender system, 'Information Technology Best Practice' identifies a number of basic recommendations, including:

- **Having an extremely robust and secure e-Tender system** - by having an enhanced security policy in place and by carrying out regular security "health checks" on the system itself and its users
- **Ensuring confidential information cannot get into the wrong hands** – for instance:
  - Whilst many aspects of an e-Tender process are similar to traditional tender arrangements, there are certain legal issues (possibly contractually binding issues) that need special consideration - for instance, people often let work colleagues check their email inbox, allowing 'unrestricted' access to dedicated e-Tender system usernames and passwords.
- **Clarification of certain 'grey areas' regarding timing of electronic tender documents** – that is, the need for an e-Tender system to automatically generated and archive dispatch and receipt times of electronically distributed/submitted tender documents.
- **Providing accesses to advanced capabilities within the system** - for instance, allowing one to compare data from project to project in order to view relative prices and timely decision-making.
- **Allowing the reuse of standard information of regular tenderers** - for instance, storing the pre-qualification documents and information of a regular pool of tenderers.
- **Tender terms, conditions, application forms, and software installation procedures (if applicable) are to be uncomplicated** to help 'persuade' certain contractors, consultants, suppliers, etc. to participate in an e-Tendering process.
- **Additional e-Tender implementation issues** that require consideration include:
  - liability for lost or corrupted data;
  - ensuring that the servers are well protected – that is, having 'fallback' plans/procedures in place for when the e-Tender service were unavailable (off-line);
  - ensuring that firewalls do not restrict the dissemination of supporting tender related documentation (ITCBP 2003).

3.2.5 Legal

Legislatures are identified as typically 'lagging' behind technical innovation and social change (Woulds J. 1997). The successful implementation of an e-Tendering process within the industry, for example, is susceptible to the current legal status regarding electronic transmissions, use of electronic signatures, etc. Furthermore, commitment by both government and industry sectors is required to help develop more innovative strategies to build a stronger and more competitive construction industry. Ongoing legal investigations, aimed at strengthening organisational and individual use of electronic communications on projects must continue, by 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).

3.3 eTender End-user Investigation

In an attempt to better understand, validate, clarify, and illustrate the meaning and step-by-step development of particular end-user *e-Tender* adoption trends, events, barriers, and perceptions ('who, 'how', 'why', 'what' and 'when'), researchers questioned a number of prequalification contractors and consultants (PQC) who used Queensland Department of Public Works (QDPW) Project Services' *eTender* system. The recommended eTender 'qualitative' guidelines (Appendix II: Table 11) are derived from 'end-user' responses to Appendix III.

3.3.1 Web Page

From an end-users perspective, an eTender Web page needs to:

- Be professionally developed and displayed.
- Be presented in a logical, clear and easy to use (user-friendly) format.
- Have an effective yet easy to use username and password access process in place.
- Remain unchanged – where system administrators are to limit changing the setup / format of the Web page.
- Have the ability to review all tender documents on the web page before actually submitting them – limiting the chance of attaching incorrect documents, etc.

3.3.2 Process / System

The eTender process/system (from an end-users perspective) should:

- 'Suit' most small, medium and large projects / construction companies; and large to medium trades – thereby Increasing end-user knowledge and awareness of an electronic tender submission process, as well as increase overall industry market awareness, experience and business opportunities. Yet, eTender administrators need to take into account that smaller projects (e.g. minor works refurbishing and alterations), usually undertaken by smaller contractors and trades (with limited ICT infrastructures in place), are typically not best suited for an electronic tender process.
- Be 'flexible' - designed on a project-to-project and region-to-region basis.
- Allow end-users to submit a tender electronically and at the last minute (timing and accuracy of the system) allowing tenderers to 'hold out' for subcontractors to submit last minute prices/quotes.
- Allow end-users to receive all tender documents and Addendums electronically - then 'seamlessly' have the capability to forward (e.g. via email) relevant documents to printers, suppliers and subcontractors.
- Convincingly reduce the need, cost and time spent in having to print, bind, and courier tender documents.
- Effortlessly, professionally and securely manage and record all Tender documents and Addendums within the system.
- 'Persuade' trades / subcontractors to upgrade their existing and/or invest in new hardware and software to take advantage of an eTender process.
- 'Encourage' the introduction of Broadband - upgrading existing phone systems to an Asymmetric Digital Subscriber Line (ADSL), thereby dramatically decreasing download time of tender documents.

3.3.3 Legal

To help overcome any 'perceived' legal issues associated with using electronic (as opposed to traditional) methods of tendering - in relation to authenticity; integrity; and

confidentiality/security - eTender process/system administrators need to ensure appropriate legal policies and processes are developed and put in place to help deal with certain 'extenuating circumstances' pertaining to the electronic submission of final tenders. That is - preventative and responsive actions that will need to be taken, for example, when an end user's own Internet Server fails, preventing a tender being submitted on time? In this case, risks can effectively be reduced by, for example, undertaking regular backups of the eTender system and by having backup servers in place.

Note:

It is not within the scope of this investigation to ascertain whether the current QDPW Project Services' eTender system addresses legislative requirements - as may be embodied in an "Electronic Transactions Act" addressing paper vs. electronic transactions.

3.3.4 Training and Education

eTender end-users all agree that administrators are to provide professional and customised (based on the various 'mindsets' of its users) hands-on training and limitless telephone assistance.

3.4 eTender Technical Investigation

As part of the QDPW Project Services' *eTender* system 'technical' investigation, researchers interviewed members of the *eTender* system*'s* technical staff, in an attempt to better understand, validate, clarify, and illustrate the eTender's system's functionality and capabilities, both from a technical perspective.

Discussions with QDPW Project Services technical staff (responsible for eTender developments) resulted in the following elaboration of certain technical issues - which were this investigation's primary focus. The recommended eTender technical guidelines in Appendix II (Table 12) are derived from this investigation (see Appendix IV).

3.4.1 Overview

To follow, a broad overview of functional and technical issues associated with an electronic system for tendering building & construction projects - as implemented within QDPW Project Services – identified during the investigation:

- Each consulting or contracting firm on the Queensland PQC Register[1] of Pre-Qualified Contractors has a unique PQC number plus an Australian Business Number (ABN), and together these items are utilised to identify firms as valid users of the Queensland Department of Public Works (QDPW) eTender system.
- Industry Policy Division of QDPW oversees the PQC Register or lists (currently held in a Lotus Notes-based computer system) which are used as a master reference, but the lists will be interfaced more directly to the eTender system in Phase II of development.
- Currently, Building Division policy specifies that only firms with a PQC Rating of Level 2 and above are eligible to participate in the eTender system.

[1] *The PQC System provides a comprehensive central register of pre-qualified building industry contractors and consultants, used by all state government departments. Only building industry contractors on the PQC Register from 1 May will be eligible to tender for government building projects valued at more than $250,000.*

Key trade and specialist contractors may also need to be registered on the PQC System if a separate project component - or trade package - exceeds $250,000. All building industry consultants must also gain PQC registration to be eligible for commissions on government building projects. A review of building industry consultants' PQC registration is due to begin mid-year. The PQC System does not apply to infrastructure projects such as roads, rail tracks, dams and bridges.

- Each Tender has a QDPW tender Project Manager (PM) who manages the Tender process including initially deciding which firms on the PQC list are invited to tender :
  - *Select Tenders* – open only to selected tenderers, and
  - *Open Tenders* – open to any tenderers on the PQC list.
- Presently there is *potential* for discrepancies caused by time lags between updates made to PQC lists and their uses made in the eTender system — although each Tender Project Manager would usually resolve any differences prior to using the PQC list of candidate firms.
- eTender users retain the option of submitting "hardcopy" (i.e. paper-based) responses for eTender jobs, however this option has not been used much by clients since the introduction of the current eTender system.
- However, QDPW currently still undertakes a number of "hardcopy-only" tenders as deemed necessary and appropriate.

3.4.2 Security

Discussions with QDPW Project Services technical staff resulted in the following elaboration of security issues:

- There is a nominated, continuing, primary e-mail contact within each firm on the PQC list, and other e-mail contacts can also be added or specified by the firm. However, as an eTender system security precaution, whenever a secondary user within a firm is detected accessing eTender information, the system routinely notifies the primary e-mail contact also.
- Each eTender system password is specific for that Tender and "one-off" for an individual firm, thus if staff leave the firm and take knowledge of passwords, etc. the current password cannot be used to access information on further future tenders. Furthermore, a tenderer's password only remains current until the date that the tender closes – i.e.: Contractor tender processes typically last 3 weeks and Consultancy offer processes typically last one week..
- Whilst a Tender remains open, if an e-mail regarding the Tender is sent to a nominated e-mail contact and it "bounces" (that is, the e-mail is returned with addressee unknown), then the PM for that Tender would normally fax or telephone the intended recipient and then make corrections to the e-mail address if it is in fact incorrect.
- QDPW advises that for audit trail purposes, normal logging of all user access to the eTender Web-server is available for perusal should it be necessary. They also advise that a standard level of back-up procedures for eTender documents are in place, with routine archiving taking place after two years of on-line storage.
- Once the eTender period closes and following evaluation by a Selection Panel and formal tender approval, the Project Manager would normally send out four (4) hardcopy plus one electronic copy (on CD) of the full documentation to the successful tenderer.
- Letter of acceptance is when the Tender is verified, and the contract becomes valid when hardcopy of the contract has been signed.
- The eTender system is housed on "dual, mirrored server" hardware (ensuring minimal downtime should one server fail or 'crash' for any reason), and is based upon Microsoft software. The eTender system utilizes Microsoft's IIS Web-server, SQLServer database software, and the ASP (Active Server Pages) approach to Web-serving.
- Microsoft's IIS (Internet Information Services) software is used as the eTender Web-server software since QDPW is for the most part a 'Microsoft shop', and maintains substantial expertise in various Microsoft products in addition to IIS.
- For added security against interference and hacking, all eTender documents are "streamed" to the server address rather than being made available to the user directly from the Web-server.

3.4.3 Network

QDPW currently utilizes CITEC[2] as their Internet service and network provider for the eTender system, however since CITEC manages the network including connections to the eTender system end-users, unfortunately it is currently not possible for QDPW to identify whether the customers access to eTender is coming via telephone modem dial-up, ADSL broadband, or via broadband cable:

- To date, most tenders released via the eTender system have resulted in low numbers of submissions (typically in the range 1–10), hence no problems or bottlenecks at peak tender submission times have been reported, but are also not expected in future. However, it should be borne in mind that users can also lodge additional documents as well as the Tender Form, and the size of these accompanying attachments could have some influence on the speed of uploading information from the tenderers to the eTender system (thus a *potential* problem for users, but not necessarily for QDPW).
- There are few, if any, reported bottlenecks with either downloading of eTender documents or uploading of Tenderers information, or the on-line completion of the Electronic Tender Form. It should be noted that *if* the eTender system is unavailable for some reason at a key period in the Tender process, it is within each tender Project Manager's capacity (after consultation with his manager) to grant an extension to the Tender time to take account of the system unavailability.
- The Electronic Tender Form is a reasonably straightforward one, and thus should interruptions to transmission occur while the Form is being completed, then the user could re-key the tender details again if the system is unable recover the partial information.

3.4.4 Document Management

- Often architectural drawings and detailed CAD plans may be necessary to supplement the textual information for the Tender, and these are routinely converted to suitable files (.tif) by a service group within QDPW (ePlan staff). Those files are then returned to the relevant Tender PM to lodge on the eTender Web site - along with any other documents that then comprise a complete package of Tender documentation.
- At this stage of eTender implementation, only e-mail (or fax, or telephone call) is used to formally communicate with the eTender customers (that is, not SMS messages, etc.).
- Under advice from their Legal and Contractual Group, QDPW staff operate on the principle that the information held on the eTender Web-site is the definitive set of documentation for each Tender, and should the information be altered or corrupted by potential users or factors in the downloading process then QDPW should not be held responsible for that.
- If alterations to the Tender are found necessary, then the original eTender document version is not amended, but rather an Addendum or full (amended) document is reissued. Users are formally notified of the issue of such an Addendum, and in fact are asked to acknowledge in the Electronic Tender Form the receipt of any such Addendum.

3.4.5 People

- Informal feedback to QDPW from users reveals a fast-growing acceptance of the eTender system, although it is also clear that many of the current users are larger companies with an adequate level of expertise in the use of ICT already within their business. Very little evidence is thus far available regarding the experience of smaller enterprises with the eTender system:

[2] *CITEC is a national Information and Communications Technology (ICT) service provider that, as a fully commercialised business of the Queensland Government, services both government and private business clients.*

- On-line “help files” for the eTender system are HTML-based, and thus can be viewed and navigated by most common Web-browser software such as Microsoft Internet Explorer and Netscape Navigator. As well, an on-line tutorial and eTender start-up guide are available for users.
- QDPW maintain a “Help Desk” staffed by Information Technology (IT) Branch during normal office hours to support their own staff, and this is used to log and assist simple queries from eTender clients, while more complex queries are logged by IT but passed across to eTender personnel to deal with. In addition, the PM responsible for each Tender is available by e-mail or telephone to assist users with specific queries regarding his/her Tender.
- As a policy, the responsible Project Manager cannot view the completed electronic Tender Forms until after the closing time and date for the Tender. This is typically around 2pm, allowing Project Managers to initiate the formal ‘paperwork’ or Tender Evaluation Form for the Selection Panel before the close of business the same day.

3.4.6 QDPW Project Services eTender Future

Discussions with QDPW Project Services technical staff resulted in the elaboration of future eTender developments:

- The system at the heart of the QDPW eTender system is also being used to ‘power’ the broader State “Queensland Government Marketplace” electronic whole-of-government tender system. This should result in additional client feedback on the system being available sooner than otherwise would be the case for the QDPW eTender system operating in isolation (www.projectservices.qld.gov.au/etenderqgm/Default.asp).
- Currently some larger firms copy the tender documentation to their own Web-site to then make it available to smaller subcontractors, but this approach could result in any subsequent changes to the Tender documents or details perhaps being overlooked for those smaller contractors. Phase II of eTender development provide a tenderer who is eligible for a specific tender, with a secondary password that can be passed on to sub-contractors and contract printers. This secondary password will enable the user to access the published tender documentation for the specific tender, but will not enable the user to submit a tender.
- Phase II will also incorporate closer integration of the PQC Register with the eTender process since the PQC re-development is being undertaken by the group within QDPW who have responsibility for the eTender (and Queensland Government Marketplace) system.
- It is also planned to include a Tender Evaluation module into the eTender system as part of Phase II of the system’s development. This will assist PM’s and the Selection Panel in rapidly and objectively assessing various elements of the eTender project’s suitability (e.g. compliance with certain requirements; local business inputs, workforce, etc.).

3.4.7 Moving Forward

The eTender system of the QDPW Project Services has been made available on a restricted scale, and is already being used successfully by a number of (medium-sized) firms in the Building and Construction industry. Similarly, to other on-line systems, eTender’s advantages over the traditional paper-based approach hinge on the ease with which a Tender Project’s plans, drawings, specifications, schedules, etc. can be made widely available. Consequently, any qualified contracting firm can download and view the “information package” of Tender documents at any convenient time, as well as having the option of subsequently lodging the firm’s response to the Tender easily and electronically (with or without adding any accompanying response documents).

The eTender system's levels of security and availability / reliability appear in line with commercial expectations, and the developments planned for Phase II will remedy any (minor) concerns that may arise from the current system's implementation. The concurrent development of the whole-of-government electronic marketplace system (based largely on the eTender 'engine') should also (hopefully) ensure that sufficient IT resources are made available to promote rapid on-going development and deployment. However, this should not be at the expense of any eTender requirements that may be thought essential for its rapid uptake specifically within the building and construction industry. As the eTender system becomes more widely used and its accessibility permeates through to the smaller building and construction firms, in common with many on-line systems, issues may well arise relating to the education and training of potential eTender users, and the ready (or otherwise) availability of technical assistance - although commercial entrepreneurs may take up the training and assistance opportunity. In addition, there are (inadvertent) effects caused by CITEC acting as an intermediary between the eTender system and the end-user, meaning that QDPW does not have knowledge of those clients' methods of connecting to the system. This means there *may* be some danger of the system development being focussed on the larger users who have good network connections in place.

It seems a little early in development to assess yet whether smaller firms (with less IT resources or in-house skills), plus those in more "remote areas" that are less well served by high-speed Internet access, are able to use the eTender system to their complete satisfaction. However, for the bulk of other users the system is emerging as a major step forward.

3.5 Summary

Construction organisations are faced with many new challenges, including the need to change current work practices; become more client orientated; competitive; and productive. 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; and continued restructuring of work practices and industrial relations. Research further indicates today's 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. Unfortunately, the nature of the industry's constructed products, its organisations and processes, limits technological change within the industry. Sharing project information electronically - from inception, design, through construction, and into building operation – can lead to large efficiency gains for all parties involved. Research suggests the eventual goal of the construction industry should be to better integrate the supply chain and all other business functions, allowing new, more efficient ways of working. The extent to which a construction company adopt these applications will depend on its specific circumstances and decisions made according to normal, sound business and strategic objectives.

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 processes, such as e-Tendering, it will limit their globalising opportunities to expand into overseas markets and allow the continuation of international firms successfully entering local markets. Researchers believe increased knowledge, awareness and successful implementation of innovative systems and processes raises great expectations regarding their contribution towards 'stimulating' the globalisation of electronic procurement activities, and improving overall business and project performances throughout the construction industry sectors and overall marketplace. Yet, achieving the successful integration of an innovative e-Tender solution with an existing / traditional process can be a complex, and if not done correctly, could lead to failure.

4 HAND-HELD TECHNOLOGY GUIDELINES

The Hand-Held Technology recommended guidelines (Appendix V) are derived from **Report 2001-008-C-06** – 'Hand-Held Technology Review' (Kajewski S.L., Tilley P.A. et al. 2003).

4.1 Introduction

It is well documented that the quality of communication and document management has great impact on the outcome of construction projects (Kajewski S.L. and Weippert A. 2003). In recent times mobile workforces have been provided with new technologies to help improve their communication and document management performance. Laptop computers provide an electronic mobile device capable of carrying large amounts of documentation and having the ability to access back-office systems through the phone-line and more recently through various wireless technologies. This addresses a small portion of the workforce that is typically site office based personnel.

More recently mobile workforces at the coalface have been given Handheld computing devices providing a much greater proportion of the construction team the ability to record data and talk to site and back office systems. This greater proportion should transfer into greater improvements in communication and document management quality, and hence, an improved bottom-line.

In order to help the Construction Industry utilise the many benefits on offer through the use of Handheld technology this chapter outlines the following:

- Information to guide in the selection of a suitable Handheld device for construction industry participants;
- Identified construction tasks suited or otherwise to the current crop of Handheld devices; and
- Future technologies that may improve the uptake and performance of Handheld devices in the construction industry.

4.2 Handheld Device Selection

Due to the wide range of tasks which are specific to certain areas of the construction industry, different devices will be suitable for different organisations/teams/individuals. This section provides information on the various options currently (July 2003) available for Handheld devices to be used as a guide to the selection of the appropriate device for each individual. Individuals work within a team/organisation and selection must consider the team/organisation existing frameworks and systems such as e.g. connectivity, platform interoperability.

4.2.1 Operating System

Selection of the operating system (OS) is one of the main criterions to consider in the selection of a Handheld device. Certain operating systems are more suited to particular applications, have different power requirements, security arrangements, memory management and protection, and supported processors. Table 1 is provided to enable a comparison of the three main operating systems used on Handheld devices today

Table 1: Comparisons of the three Main OS System Features

FEATURE	PALM	SYMBIAN	WINDOWS CE
User Management	Traditionally, single user system. Can be multiuser as well.	Typically a single user operating system	Typically a single user operating system
Task Management	It provides for only a single application to be running at a time, but other applications can be called from another, so switching between applications is facilitated. Internally, multi tasking is done in Palm.	Real-time microkernel with low-interupt and task switching latency provides multitasking with pre-emptive, priority driven scheduler.	Supports 32 simultaneous processes and unlimited number of threads, limited only by physical memory
Power Management	Palm OS has different power operation modes to save power: sleep, doze and running.	None	None
User Interface	Easy to access applications and user friendly in operation, recognizes only Palm handwriting alphabet.	The EIKON handle all interface related elements including buttons, dialogs and menus. The Symbian OS supports display, keyboard and sound.	Windows CE provides menu controls, dialogs and supports sound. The similarity of the interface with the windows desktop is distinct market advantage.
Memory Management	Divided as follows: **Dynamic heap:** for storing global variables for program execution, stack and dynamically allocated memory, inline with a RAM of a desktop OS. **Storage:** this holds permanent data, such as databases, files and application codes, and is therefore not cleared on reset.	Symbian has a memory management unit (MMU) concept to provide separate address spaces for each application.	A protected virtual memory system that supports up to 32MB memory per process protects applications against each other.

Security	none	Low	High. Windows CE has support for cryptography with a cryptography library (Cryptographic Application Programming Interface CAPI) to securely store information in memory. Additional data security can be achieved by using the smart card interface of Windows CE.
Memory Protection	None	Yes	Yes
Supported Processors	Motorola Dragon Ball	NEC ARM	X86, ARM, MIPS SH3/4, PowerPC
Hand Held Usage (typical)	PDA	SmartPhone	PDA

(Lukmani M. 2002)

Another widely used operating system on Handhled devices is the Linux OS. This Linux OS is said to be ideal for situations where in-house development of the system is required. It is also said to be much more stable and secure than other systems and therefore less likely to be affected by virus attack. Table 2 lists the majority of the operating systems in use on today's hand held devices.

Table 2 Operating System on current Handheld devices.

MANUFACTURER	OPERATING SYSTEM
3Com	Palm
Microsoft	Windows Pocket PC; Windows CE; Windows CE.Net; Windows Smartphone, Windows XP
Symbian	Symbian (formerly EPOC)
Various	Linux
Research In Motion	Blackberry
Vtech	VT
Franklin	eBookMan
Apple	Newton (now defunct)
Casio	PV
IBM	DOS
SavaJe Technologies	SavaJe (Java Based)

4.2.2 Processor Speed

Processor speed is an easy choice when selecting a Handheld device, as in most cases the selection is based on the premise that faster is better. In recent times Handheld devices have more than sufficient processing speed to enable efficient usage for most applications. One thing to look out for is between manufacturers, processing speed varies and may not be directly comparable. For palm operating systems, which typically require less processing than their Windows equivalent, the specified speed for the processing unit may be slower. However, the actual speed of processing the applications may be equivalent to that of a Windows OS which has a faster specified processing speed. Currently typical high-end devices have processing speeds of 33-200MHz for the Palm OS and 200-400MHz for the Window OS devices.

4.2.3 Read Only Memory

Read Only Memory (ROM) is "built-in" computer memory containing data that normally can only be read, not written to. ROM contains the programming that allows the Handheld device to be "booted up" or regenerated when turned on. Unlike random access memory (RAM), the data in ROM is not lost when the computer power is turned off. Once again the larger the ROM the better when it comes to selecting a Handheld. Typical High-end specifications of ROM for Handheld devices are in the 32-48 MB range. Any device below 16 MB of ROM would be considered outdated.

4.2.4 Random Access Memory

Random Access Memory (RAM) is the place in a Handheld device where the operating system, application programs, and data in current use are kept so that they can be quickly reached by the Handheld's computer processor. RAM is much faster to read-from and write-to than the other kinds of storage on the Handheld. However, the data in RAM stays there only as long as the Handheld is running and is lost once it is turned off. When the Handheld is turned on again, the operating system and other files are loaded into the RAM. Typical High-end specifications for RAM are in the range 64-128MB. Anything lower than 32MB of RAM would currently be considered outdated. However, RAM is widely available as an add-on, therefore can be easily supplemented if the device chosen does not provide the required storage.

4.2.5 Connectivity Options

Synchronisation of files etc. between the PC and Handheld devices is mostly carried out through hard wired USB port enabled cradles. The Handheld is physically attached to the cradle which is connected to the PC USB port (typically) by cable. This allows the mobile worker to synchronise documents and PIM applications with network and PC hard drive versions allowing the field worker to work on documents externally to the network and PC hard drive whilst on-site. This type of connectivity is suitable for workers that are only required to connect at the beginning and end of a shift.

Wireless connectivity can provide the mobile worker real time access to organisation centralised networks that are either based on-site or at central office locations. In the case of on-site based networks the currently viable options include Infrared, Bluetooth and Wi-Fi. The term viable in this case refers to the financial constraints placed on the use of Wide Area Network (WAN) options within a range of 200m.

Infrared provides short range (up to 1m) and line of sight connectivity, and is currently available as a standard inclusion on most PDA devices. Typical applications include beaming of electronic Business Cards and files between enabled devices. Bluetooth is essentially aimed at connecting to individual devices such as printers, PCs and other Handhelds within a range of approximately 10m, and 100m with an amplifier. The Infrared and Bluetooth connectivity is mainly used for data transfer e.g. transferring files etc. from computer to computer, although Bluetooth technology allows wireless synchronisation of Personal Information Management (PIM) applications such as MS Outlook information from Handheld device to Bluetooth enabled PCs or Laptops.

Wi-Fi or 802.11b as it is commonly known is aimed more at the network application where a Wi-Fi enabled server allows Wi-Fi enabled devices to connect to the network within a range of approximately 200m. The Wi-Fi option is suitable for large vertical construction sites where the cost of implementing the complete network solution on-site is feasible.

For situations where the field worker is required to wirelessly access the network from distances greater than 200m, Wide Area Network (WAN) capable devices are used. These are Handheld devices that have mobile phone capabilities. The field worker dials up and wirelessly connects to the organisation's network using it's phone capabilities. There are quite a number of devices that have built-in phone capabilities, however there are also add-ons that give phone capability to Handheld computing devices. Currently the main constraint on WANs is cost, both in the initial capital outlay for the device (approx $AUD1300) and ongoing service, where unless access is critical, the cost may outweigh the benefit.

To date there are only a few Handheld devices that have multiple wireless connectivity options built-in, and they come at a substantial price. Once again this is dynamic and with time Handheld devices will have many wireless connectivity options built-in and at a feasible cost. The Personal Data Terminal (PDT) devices appear to be at the forefront in wireless connectivity inclusions either as built-in option or through add-ons. Already there are several devices that have Infrared, Bluetooth and Wi-Fi built-in. In the interim connectivity is available for Handheld devices through add-ons. Therefore, when selecting a Handheld device based on connectivity, the available add-ons and their mode of physical connection to the device needs to be considered.

Table 3 Wireless Technology Comparisons of Main Features.

WIRELESS TECHNOLOGY	ELECTROMAGNETIC RADIATION SPECTRUM	RANGE (M)	DATA DOWNLOAD RATE
Infrared	2.4 GHz	Up to 1	Up to 16 Mbps
BlueTooth	2.56 GHz	Up to 10 Up to 100 with amplifier	Up to 721 Kbps
Wi-Fi	2.4 GHz	Up to 200	Up to 11 Mbps
GSM	900 and 1800 GHz	Limited by Service	Up to 14.4 Kbps
GPRS	900, 1800, 1900 GHz	Limited by Service	Up to 150 Kbps
CDMA	800 and 1900 GHz	Limited by Service	Up to 115 Kbps
EDGE		Limited by Service	Up to 384 Kbps
UMTS	1885-2025 MHz (IMT-2000) 1980-2010 MHz & 2170-2200 MHz (Satellite Portion)	Limited by Service	Up to 2 Mbps
WCDMA	5 MHz	Limited by Service	Up to 2 Mbps

4.2.6 Ruggedness

One characteristic that is important for construction type applications is a Handheld's ruggedness or it's ability to resist the adverse environmental conditions that may occur on a construction site e.g. dust, water. There are devices that are inherently more rugged, these tend to be the Personal Data Terminal (PDT) based devices, which had their origins in other industries and were used mainly for their automatic data collection capabilities i.e. Bar Code scanning and Radio Frequency IDentification (RFID) applications. These devices meet the required standards regarding dust and water intrusion and typically, the manufacturers indicate the level or the standard/s met by each device. There are also add-ons that give the required level of ruggedness to the more standard Handheld devices such as the traditional PDAs, which were originally developed for the office based worker.

4.2.7 Data Collection

Automatic data collection is possibly the number one application for productivity improvements that Handheld devices have to offer the construction industry in the

foreseeable future. Bar code readers and RFID tags provide improved data collection systems over traditional manual data entry. Some documented applications include materials inventory at the construction gate and tracking of assets during their lifecycle. The PDT devices typically have Bar Code and RFID readers as a built-in option. Currently there are Bar Code reading add-ons available for the basic PDA device. RFID is a relatively new technology and is not widely available on Handheld devices in general. The RFID tagging system allows greater functionality through the ability to edit and add information on an asset e.g. updated maintenance. Obviously, the usefulness of these types of readers is reliant on the upstream suppliers of the items to be read, particularly in the case of bar code readers.

One common practice for the construction industry is the use of digital cameras for the recording of various site related activities to complement traditional diary entries. Currently in most cases the digital cameras available on the current crop of Handhelds are of not sufficient quality for professional recording of construction data. However, the quality is improving quickly and in the not to distant future they will be of the required quality. In the interim, it is suggested that a dedicated digital camera be used for recording construction data. It is still possible to view the digital photos if one ensures that the Handheld device has the ability to transfer data through add-on interoperability with the dedicated digital camera.

4.2.8 Add-on/Expansion capability

As mentioned previously the capability of a Handheld device can be greatly enhanced through the use of expansion slots. The type of slots available include:

- Secure Digital (SD)/MultiMediaCard (MMC) slot;
- Compact Flash Slot (CF)/Microdrive slot;
- Springboard Slot (Handspring);
- PC Slot; and
- Memory Stick slot.

Therefore, if the required functionality is not provided as a built-in, then one must ensure that the appropriate functionality is available as an add-on and hence the corresponding add-on physical connection type slot is included on the device. Table 4 provides a brief description of the types of add-ons available for Handheld devices on the market today.

Table 4 Add-on capabilities available for Handheld devices.

ADD-ON CAPABILITIES FOR HANDHELD DEVICES	
TYPE	**DESCRIPTION**
Portable Keyboards	Folding keyboards
GPS Navigator Kits	Clip-on GPS devices
Memory Expansion	Plug-in additional memory: CF cards, Microdrives, SD cards MMC cards, Memory Sticks.
Printers	Clip-on printer
Modem Connectivity Kits	Clip-on modem for the Internet
Wireless Headsets	BlueTooth Headsets for voice communication
Car Lighter Sockets	12 Volt plug-in for car lighter sockets
Cameras	Digital clip-on cameras
WLAN Module	Clip-on Wi-Fi capability
Multimedia Expansion Jackets	Allows output to TV, Projector or VGA monitor
MP3 Audio Kits	Allows reading of MP3 files
Mobile Phone	Clip-on GSM phone capabilities for PDA.
PDA	Clip-on PDA functionality for mobile phones.
Digital Voice Recorder	Plug in Digital Voice Recorder.
Language Translator Cards	Expansion card for language translation.
Bluetooth sleds	Clip-on Bluetooth capabilities
WAN CF Card	CompactFlash Card enabling GSM/GPRS
Bar Code Module	Slip on plug-in Bar Code capability.
3G Card Modem	Card modem enabling UMTS.
Bar Code CF Card	CompactFlash Card enabling Bar Code Scanning capabilities (Wand Type)
Protective Cases	Clip-on cases with dust, water etc. protection in line with PDT devices.
Orientation Driven Navigation	Expansion Card allows navigation of screen by orientation of device.
Power Charger	Solar powered battery charger
Eyewear Mounted Monitors	Plug-in full size virtual 15” VGA screen image

4.3 Construction Specific Software

If the field worker has wireless access to the site/back office system with their Handheld device they are able to access very sophisticated construction software applications through a web browser. The types of access can be either through an Application Service Provider (ASP) or Client/Server type arrangement. The difference being that the ASP is a third party foreign to the project, which hosts the software and data, only supplying a service to the project senior organisation, typically the Main Contractor. In the case of the Client/Server arrangement, the host is the senior organisation in the project that owns the data and purchases the software and hardware, serving the various project participants.

These types of arrangements are suitable for Handheld devices because they allow the client to be thin, where one only requires a web browser to utilise very sophisticated software applications. There are also available on-device versions of leading construction management software e.g. Primavera Systems-Mobile Manager and Meridian Project Systems-Prolog Pocket. These systems allow the field worker to work on the software off-line and then upload to the network version either wirelessly or through USB synchronisation system. With any software application there is a minimum requirement for both Random Access Memory (RAM) and processing speed. Therefore, one has to consider the ability of the Handheld device to expand it's RAM through add-ons to keep up with the requirements of the software applications. The following list (Table 5) provides a comprehensive summary of the types of construction specific software that is available on a Handheld device either through ASP, Client/Server or On-Device Software:

Table 5: Construction Specific Software Available On Handheld Devices

CONSTRUCTION SPECIFIC SOFTWARE AVAILABLE ON HANDHELD DEVICES			
2D & 3D CAD	Accounting	After Sales Service	Bidding
Business Development	Certification Tracking	Change Order Management	Client Management
Code Checking	Commissioning Management	Communication Management	Contact Management
Contract Management	Contractor Management	Cost Control	Design Management
Diary Document Management	Drawing Register	Earned Value Management	Equipment Management
Estimating	Feasibility Analysis	Financial Analysis & Management	HR & Training Management
Knowledge Management	Land Acquisition	Marketing	Materials Management
Milestone Tracking	Option Management (Project Home Builders)	Payroll	Performance Management
Procurement Management	Productivity Analysis	Project Collaboration	Project Scheduling
Project Variance Analysis	Purchase Management	Quality Control	Resource Management
Risk Management	Safety Management	Sales Management	Stores Management (Stock Control)
Tender Management	Time-Attendance Management	Tool/Plant Management	Virtual Design Centre

As can be seen, the full gamut of construction activities/tasks is covered by the available software that can be accessed by Handheld devices. The main things to consider as far as Handheld device selection and software, include:

- Is the Handheld device required to have web browser access to software;

- Is the processor speed and RAM adequate to support the likely software applications to be used; and
- Is there the add-on capability to increase RAM to support future software application requirements.

4.4 Suitable Applications

The uptake of Handheld devices in construction appears to be very limited. A survey of the Queensland (Australia) construction industry (conducted as part of a broader research project), found only 24% of respondents occasionally require the use of Handheld devices. With this in mind the information available on their benefits for construction is very limited. However, anecdotal evidence suggests that their use on any task/activity that requires a doubling of effort, such as diary data entries and data entry in general, would provide productivity improvements. Moreover, anywhere that an automatic collection of data is possible through this type of technology would provide even greater productivity improvements to the types of tasks already mentioned.

From case studies reviewed (Reboli D., Magdic A. et al. 2000; Bowden S., Thorpe S. et al. 2002; Saidi K.S., Haas C.T. et al. 2002) in general it was found that Handheld devices have the ability to improve construction productivity. Tables 6-8 are provided as a guide to the types of construction activities or tasks which are suited, or otherwise, to Handheld computing devices.

Table 6 Tests Results for Hypothetical Construction field activities

TESTS RESULTS FOR HYPOTHETICAL CONSTRUCTION FIELD ACTIVITIES			
ACTIVITY	**ELEMENTARY TASKS ELIMINATED**	**ACTIVITY CYCLE TIME REDUCTION (%)**	**OVERALL POTENTIAL DELAY REDUCTION (%)**
Punchlisting	14	40	50-70
Materials Tracking	9	26-51	88-95
Materials Safety Data Sheets	5	59-71	65-75
Drawing Access	3	70	64-72
Requests For Information	1	16-23	83-91
Quantity Surveying	6	60	N/A

(Saidi K.S., Haas C.T. et al. 2002)

Table 7 Examples of Tasks Suited and Not-suited for Handheld Devices in Construction

HANDHELD DEVICES IN CONSTRUCTION		
NO.	**TASKS THAT ARE SUITED**	**EXAMPLE**
1	Tasks that require access to large amounts of text information	Reading MSDS sheets, building codes, knowledge base, etc.
2	Tasks that require viewing a small detail of a document	Viewing close-up of a steel beam connection diagram
3	Tasks that require the entry of binary data	Answering yes/no questions, checking-off items on punch lists
4	Tasks that require the entry of data into a form	Filling-in a safety or equipment usage report, recording material receiving information, etc.
5	Tasks that require instant transfer of small amounts of information to and from a network.	Sending and receiving e-mails, looking up the latest material procurement information.
NO.	**TASKS THAT ARE NOT SUITED**	**EXAMPLE**
1	Tasks that require computer processing power comparable to that found in desktop computers	Editing a 3-D construction drawing
2	Tasks that require a "big-picture' view of a document	Viewing a drawing or a network schedule
3	Tasks that require a constant (i.e., always on) connection to a computer network	Working with data stored on a mainframe
4	Tasks that require a considerable amount of manual data entry (or writing).	Writing a progress report
5	Tasks that are likely to be performed mostly in direct day light, or under very bright artificial lighting	Working with no roof overhead during the day
6	Tasks that actually put work in place	Nailing, cutting, digging and etc.

(Saidi K.S., Haas C.T. et al. 2002)

Table 8 Usefulness Survey Responses

USEFULNESS SURVEY RESPONSES	
TASK	**RATING**
Method Statements	3.8
Drawings	3.6
Inspection test sheets and similar documents	3.5
Diary	2.9

(Bowden S., Thorpe S. et al. 2002)

Bovis Lend Lease (UK) has used an RFID tagging system for deliveries during construction and maintenance. They identified the following benefits (Technology-Watch 2003):

- A reduction in the number of lost delivery notes and payment delays: resulting disputes can cost 15000 Pounds or more to resolve on a typical project;
- Improved material management: trials indicate a 2 to 5% saving in material costs;
- Greater maintenance productivity by giving engineers, as well as clients, instant access to maintenance history, settings and other essential information; and
- Reduction in defects: defective items are identified, tracked and replaced.

A study led by the Building Research Establishment (BRE) in the UK on RFID technologies identified future prospects for this technology in the construction industry. Some examples of the possibilities currently available on several Handheld devices include (BRE 2002):

- Tracking reinforcement throughout the installation process. This will include confirmation of handover status and updating of the CAD model from the handheld. They will also be able to identify the correct building component for installation using the RFID tags and download CAD drawings showing where and how to install the component and how to observe the health and safety requirements; and
- Linking RFID tags to CAD based asset management tracking systems. With an Internet enabled Handheld scanner information such as health and safety requirements, maintenance notes can be accessed and edited.

4.5 Future

Case studies mentioned in Section 4.4 (Reboli D., Magdic A. et al. 2000; Bowden S., Thorpe S. et al. 2002; Saidi K.S., Haas C.T. et al. 2002) also found that there are several limitations placed upon the current crop of Handheld devices e.g. small screen size, cumbersome data entry and navigation. This section is provided to highlight the research and development that is currently looking to address the identified (as well as others) problems with the current crop of Handheld devices. These developments should improve both performance and uptake of Handheld devices in the construction industry.

4.5.1 Improved Communication Networks

One of the main improvements which will facilitate the uptake of Handheld devices among field construction personnel is likely to be the improvement in WANs. At present the systems are slow and the cost of downloading is a definite barrier to it's uptake. This refers to Third Generation (3G) communication systems and beyond (4G, 5G, ...). What this will bring is much faster data download rates, where 3G is expected to provide up to 2Mbps. As the uptake improves and economies of scale kick-in, the cost of the service will reduce, possibly making WANs the standard data transfer system for mobile business users across the board.

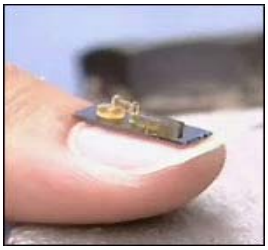
4.5.2 Two-Way Human-Computer Interaction

Sprint Advanced Technology Laboratory has been developing what is known as "Intelligent Agents" for several years. These intelligent agents are able to carry out verbal requests. The long-term goal for Sprint is to enable the user and the intelligent agent to communicate seamlessly, whether using a desktop or Handheld device (Louie D. 2001). This technology provides huge potential for automated processing of current cumbersome data entry applications. It also gives an added dimension to current automatic data collection technologies, where the data is not only collected by the handheld device, it is processed and tasks are carried out based on the data input, providing further productivity improvements.

4.5.3 Future Power Options

Improvements in the way Handheld devices receive their power generation is one area that is being investigated by several organisations. The more functional that Handheld devices become the greater drain on the power supply. The following briefly discusses some of the future technologies that will be powering devices more efficiently and effectively in the future. There are several future power source technologies looking to address this problem including: Fuel Cells, Silver Polymer Batteries (Hardy E. 2003b), Photovoltaic & Hydrogen Fuel Cells and Micro-engines. Fuel cells create power by converting methanol into water. Direct methanol fuel cells provide five times higher energy density than rechargeable lithium-ion batteries widely used on the current crop of Handheld devices. Silver Polymer battery prototypes have achieved over 2 kilowatts per litre, which is several times the power level of lithium-ion batteries. A prototype combination of photovoltaic and hydrogen fuel cells has been developed for the cover of a Casio Handheld device. The output from this technology is 35 milliamps per square centimetre in direct sunlight. Researchers at Birmingham University are developing tiny motors or micro-engines, which are a couple of millimetres in size but are able to generate up to 300 times as much energy as an ordinary battery.

Figure 1 Micro-engine technology.



(Hardy E. 2003)

4.5.4 Keyboard Technologies

As mentioned previously one of the drawbacks for Handheld computers is the difficulty in entering data. Although there are add-ons that provide full keyboard functionality, having to carry around this type of equipment is not suitable for the mobile worker. One solution is to create a keyboard which is in a sense not there i.e. virtual and physically unburdening. There are currently two developments trying to address this problem using laser and infrared technology. VKB Ltd is developing a virtual keyboard (Figure 2) by projecting a laser image onto a flat surface. They are allowing for the situation where a flat surface is not available by the inclusion of an alternative text entering system (Hardy E. 2003).

Figure 2 Virtual keyboard through laser imaging.

(Hardy E. 2003)

HoloTouch, Inc has developed a holographic keyboard incorporating infrared technology. In this case a 3D image of a keyboard floats in the air in front of the user. An infrared detector scans the plane of the holographic image to detect which character is being keyed. This technology is already commercially available in the form of touch-less information kiosks. The challenge is being able to reduce its current size to fit into a Handheld device (Hardy E. 2003b).

4.5.5 Random Movement Printing Technology

Although not identified previously as a drawback to the use of Handheld devices the ability to print decent sized documents away from the office printer is still one limitation. In order to address this problem PrintDreams has developed a new technology called Random Movement Printing Technology (RMPT). The PrintBrush printer is a concept design using RMPT. Text and pictures are loaded onto the PrintBrush from a Handheld-computing device using BlueTooth. The PrintBrush device is swept by hand across any type of paper, irrespective of dimensions, simalteneously printing the scanned images/text. The approximate dimensions of the printer are the length of a pen and thickness of a mobile phone, allowing it to fit into the pocket. PrintDreams expects these will be commercially available sometime in 2005 (Hardy E. 2003).

Figure 3 Prototype random movement printing device

(Hardy E. 2003)

4.5.6 Flexible Handhelds

Sony is developing prototype flexible Handheld devices. The latest version is called the Gummi, which is controlled by bending the device. Piezoelectric pressure sensors and a touch panel are built into the device. It is essentially a data collection device only, without the ability to enter text and the like (Hardy E. 2003).

Figure 4 Flexible Handheld prototype Gummi by Sony

(http://zdnet.com.com/2100-1103_2-1022554.html)

4.5.7 Wearable Computers

A competing technology for Handheld devices is emerging in the form of wearable computers. This seems to be a natural progression for mobile technologies to take, where in the first instance mobile Handheld computers are being used to improve the capability and efficiency of the mobile workforce. Wearable computers offer much greater potential benefit to the mobile worker through the greater efficiencies provided by increased automation as well as human computer indirect interaction. The main objective of wearable computers is for the computer to carry out the users required tasks without any direct user interaction.

4.6 Summary

When selecting a suitable Handheld device for construction applications the main things to consider include:

- Individuals working within a team/organisation and selection must consider the team/organisation existing frameworks and systems such as e.g. connectivity, platform interoperability.
- Operating System: Different operating systems have different characteristics and are more suited to specific tasks and customisation, including:
  - Task Management;
  - Power Management;
  - User Interface;
  - Memory Management;
  - Security;
  - Memory Protection;
  - Supported Processors; and
  - Typical Hand Held Usage.
- Processor Speed: Generally the faster the better. Specified processor speeds between devices with different operating systems may not be directly comparable i.e. some operating systems require less processing than others, and therefore, the net speed may be similar. Typical ranges are 33-200MHz for Palm OS devices and 200MHz-400MHz for Windows OS devices.
- Read Only Memory (ROM): The larger the better. Presently typical of High-end devices is 32-48MB of ROM.
- Random Access Memory (RAM): The larger the better. Need to check the required level software applications to be used. However, RAM expansion is available through add-ons.
- Connectivity Options: Need to consider the type of construction jobs i.e. Horizontal or Vertical in relation to their distance from available site/centralised network office locations or individual devices to connect.
  - For field workers that only require synchronisation of data at start and end of shift, USB hard wired cradle is suitable;
  - For connectivity to provide data transfer within a range of 1m and in line-of-sight then Infrared (Irda) is suitable;
  - For connectivity to provide data transfer and PIM synchronisation type applications within a range of 10m (100m with amplifier), Bluetooth technology is suitable;
  - For full network connectivity within a range of 200m, Wi-Fi is suitable. Need to consider the cost of setting up the Wi-Fi enabled server not just the individual devices; and
  - *For* full network connectivity greater than 200m (within a range limited by service only), WAN communication systems are suitable. Currently available systems include GSM (2G), CDMA (2G), GPRS (2.5G), EDGE (3G), WCDMA (3G), UMTS (3G). Cost and data download rate needs to be considered, currently slow and expensive respectively, however, they are improving exponentially.

- Required Ruggedness: Need to consider the type of applications and environmental conditions (dust, water) that the device is likely to be subjected. PDT and PPT devices are inherently ruggedised. The traditional PDAs are able to be ruggedised through add-ons.
- Data Collection: Automatic data collection is available through various technologies either built-in or as an add-on including:
  - Speech: including Speech Recognition, Text to Speech and Interactive Voice Response.
  - Bar Code Reading;
  - Radio Frequency IDentification (RFID); and
  - Finger Print Sensing Technology.
- Add-on/Expansion Capability: As mentioned previously the capability of a Handheld device can be greatly enhanced and/or brought to speed through the use of expansion slots. The type of slots currently available include:
  - Secure Digital (SD)/MultiMediaCard (MMC) slot;
  - Compact Flash Slot (CF)/Microdrive slot;
  - Springboard Slot (Handspring);
  - PC Slot; and
  - Memory Stick slot.

There are currently available software applications that cover the full range of construction related activities. The things to consider in relation to the selection of a Handheld device and the available software are how it will be accessed and what is the RAM requirements. If it is to be accessed through a web browser (ASP or Client/Server) then the Handheld device will require Wireless Application Protocol (WAP) capabilities. If the software is loaded on the device then the required RAM must be considered provided either as a standard inclusion or as an add-on.

In general, anecdotal evidence suggests that Handheld devices provide improved productivity through the reduction in doubling of effort. A case study by Saudi et al (2002) identified construction activities/tasks that are suited to Handheld devices:

- Tasks that require access to large amounts of text information;
- Tasks that require viewing a small detail of a document;
- Tasks that require the entry of binary data;
- Tasks that require the entry of data into a form; and
- Tasks that require instant transfer of small amounts of information to and from a network.

The current crop of Handhelds provides improved productivity over traditional systems. However, they are not without their technological limitations identified as being small screen size, cumbersome data entry and navigation. To overcome the limitations due to screen size emerging technologies such as Orientation Driven Navigation, Near Eye displays have and are being developed. Other emerging technologies that are looking to improve current Handheld devices include power sources (Fuel Cells, Photovoltaics, Micro-engines, Silver Polymer batteries) keyboards (Virtual Laser image, Holographic), printing (Random Movement technology), navigation (Flexible Handhelds).

Looking to the future it appears the traditional Handheld computing devices will be competing with Wearable Computers. Wearable computers provide greater potential benefit to the mobile worker through greater use of automated processes. In a sense, the Handheld devices of the present and in the near future are a testing ground for some of the technologies slated for wearable computers in the more distant future.

5 CULTURE CHANGE GUIDELINES

In an attempt to demonstrate leadership in implementing a cultural or technological driven change within the AEC industry, 2001-008-C-05 researchers (through industry wide literature reviews) identified 24 'general' industry 'Culture Change Guidelines' (Appendix VI). These guidelines are derived from **Report 2001-008-C-05** 'Industry Culture: A Need for Change' (Kajewski S.L. and Weippert A. 2003).

Note:

Report 2001-008-C-05 is a preliminary literature investigation into 'general' public and private industry organisational need for culture change. Where 'general' industry organisation experiences, characteristics and cultural attributes (as identified in this investigation) are considered 'background literature' to an on-going and in-depth PhD investigation into AEC industry specific organisations and project team member values, attitudes and beliefs, etc. towards a technology driven culture change. The ongoing PhD research activities focus on identifying and clarifying the 'need' for change by examining AEC industry specific cultural and sub-cultural 'threats' and 'opportunities' that challenge the successful uptake of innovative Information and Communication Technology (ICT) solutions within and between organisations and project teams.

5.1 Introduction: Why Culture?

'Culture' - identified as one of the most difficult and complex approaches to understand. This is mainly due to culture being defined in so many different and sometimes conflicting ways (Pepper G. L. 1995). Based on various literatures, culture:

- "*Begins to form wherever a group has enough common experience" which inturn becomes the "property of that group*" (Schein E. H. 1999) p13.
- "*Is influenced by traditions, myths, history and heritage...it is the sum of how we do things around here*" (Hensey M. 2001) p49.
- "*Pervades the decision-making and problem-solving process of the organisation, influencing the goals, means and manner of action…a source of motivation and de-motivation, of satisfaction and dissatisfaction, thereby underlining much of the human activity in an organisation*" (Williams A., Dobson P. et al. 1993) p15
- "*Is a pattern of shared basic assumptions that has been learnt whilst solving problems, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems*" (Schein E. H. 1997) p12

"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. When we know its role, we can comprehend its importance"
(Williams A., Dobson P. et al. 1993) p11.

In today's increasingly competitive and ever changing AEC industry environment there are no 'quick fixes' to truly help deliver long-term excellence within individual organisations, groups and project teams. The pace, size and complexity of change is greater than ever before, overwhelming many of those who face it. Changes such as:

- The need to transform a business that succeeded for years by focussing on customer service that must now focus on technical proficiency to keep up with increased domestic and global competitiveness;
- Redesigning and adapting existing jobs to incorporate these new and never used before technologies; or

- Transforming the current culture and sub-cultures of an organisation from, for example, a cautious or 'reactive' culture, to a fast or 'first-mover' (Black J. S. and Gregersen H. B. 2002).

Research further indicates, one of the last available 'mechanisms' left for organisations to improve their competitive position within the AEC industry is by considering its people (culture) along with its technology. In other words, if one wants to make AEC industry organisations, groups and project teams more efficient and effective, then one must better understand the role that culture plays within them (Schein E. H. 1997). There are arguably many reasons why the study of an organisation, group or team's culture is important, including:

- Culture focuses on communication at all levels of a hierarchy, where individuals identify who they are in relation to one another and their environment, and where shared understandings form identifiable subgroups / sub-cultures.
- By focusing on culture, one inevitably focuses on the daily routine and 'sense-making' that is the process of building identities and shared reality among members.
- A cultural approach focuses on largely ignored issues such as assumptions and brings underlying values and motives to the surface.
- The understanding of culture offers a better insight to the managers and leaders – not in order for them to better shape the culture, but to better understand and participate in the 'sense-making' activities of members.
- Undertaking a cultural approach will help identify novel approaches and understandings of future organisations, groups and teams.
- Finally, culture is pervasive, not simply a variable that affects the organisation, group or team, but indistinguishable from it (Pepper G. L. 1995).

5.2 Change Methods

Changing the culture of an organisation and its members takes time. That is because it is a slow process for people in existing or newly established 'social systems' to develop a new set of common held beliefs, attitudes and values (Williams A., Dobson P. et al. 1993). Today's industry organisations are using a wide variety of mechanisms in an attempt to change their culture.

5.2.1 Need for Change

"If you do not see a truck racing towards you, you are unlikely to jump out of the way…likewise, if you do not realise that you are standing on a treasure of gold, you are unlikely to bend down and pick it up" (Black J. S. and Gregersen H. B. 2002) p20.

The above phrase reinforces the importance for organisations, groups and teams to realise and create a 'need' for change, before the act of change can take place. For the industry to be convinced of the need for change is easier said than done, because people tend not to see even the most obvious threats and opportunities because they are 'blinded' by the '*way we have always done things around here*'.

If people fail to see the need for change (whether threat or opportunity drives it), they will not change" (Black J. S. and Gregersen H. B. 2002) p20.

5.2.2 Motivate People

The first method to motivate people to change is when they are confronted with a real or perceived threat (e.g. job security, increasing competition, etc), which inturn motivate short-

term behaviours. The second method is through real or perceived opportunities (e.g. improved profitability, greater productivity, increased employee development, etc), which inturn motivate long-term behaviour within an organisation. Importantly, the real or perceived threats and opportunities will vary from organisation to organisation, where certain key threats and opportunities are better or worse for one but not the other.

5.2.3 Change Strategy

Many organisations decide to change their existing culture based on the need to implement a strategically driven change, due to a certain 'crises' or 'opportunity' being identified – i.e.: many organisations are driven to change due to business demands, not necessarily by the need to change culture. Yet, this change strategy requires a change in organisational objectives, work methods, habits, systems, structures, training, and the way people '*think or do things around here*' (i.e. culture). The successful change in culture can therefore promote a strategic change, but if not properly implemented and managed, both existing and 'enforced' culture groups may constrain a new business strategy (Williams A., Dobson P. et al. 1993; Bate P. 1996; Schein E. H. 1999).

5.2.4 People and Places

By changing people - particularly those in key positions or with more uncompromising attitudes - one may change the pattern of beliefs and attitudes within the organisation more easily. A further attempt in changing an existing culture is to 'reshuffle' or 'rotate' groups and/or individuals (with different knowledge, experiences and learning), and moving them into key positions within other sub-cultures (sections / departments, etc).

5.2.5 Beliefs, Attitudes and Values

Due to beliefs of individuals being influenced by or formed through observation, interaction, participation, and persuasive communication, organisations may use one or more of the following methods for changing the beliefs, attitudes and values of their employees:

- **Through use of role models:** By recognising the importance of senior / key individuals, acting as role models to achieve the desired attitudes and behaviours of employees.
- **Through participation:** Formalised group discussions, such as morning meetings, team briefings, etc., as methods for developing shared beliefs and attitudes.
- **Through use of formal communication:** Although a common process, it can be used more extensively and effectively by formally 'communicating' the organisation's culture to their employees and local community from which they recruit the majority of their employees through in-house or external corporate advertising media groups and, for example, publishing articles entitled '*Protecting Customer Investment*'; '*Putting the Customer First'*; or '*Responding to Change Demands*'.
- **Through counselling:** When, for example, there is a need for an organisation to make significant reductions in staff in order to cut costs and improve its profitability, it is difficult to promote a proactive and positive culture at the same time. Therefore, in order to encourage and maintain a positive culture, research suggests each level of management carry out one-on-one consultations with their employees prior to, during and after the change process.
- **Through Management education:** Educating management using external consultants is a central strategy for many organisations to achieve a cultural change. On completion, managers are to run 'customised' internal programs to help 'cascade' this newly acquired culture change knowledge and management process down to the rest of the staff.

5.2.6 Structures, Systems and Technology

Changing the structure of an organisation will usually make some, and rather unpredictable, impact on its culture – i.e.: influencing existing work groups and communication networks. However, through revised or improved reward, appraisal, monitoring, budgeting and control systems, found to be linked to specific behaviours, are largely more capable of changing people's beliefs and attitudes towards performing in particular ways.

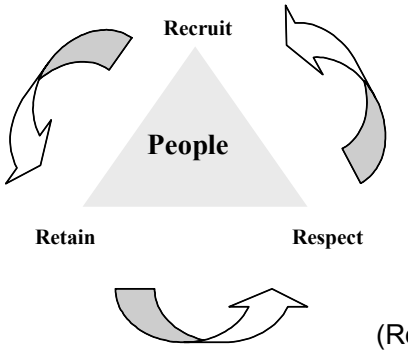
5.2.7 Corporate Image

By promoting an improved corporate image (via name, logo, advertising, publication of success, etc), typically develops positive attitudes among both customers and staff and enhances their overall commitment towards the organisation.

5.2.8 Invest In People

Research 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. Therefore the most urgent business challenges currently facing the industry is not the implementation of innovative technologies, but 'looking after people' (Figure 5) – i.e.: 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 J.G. 1999) where '*holding on to good people'* is regarded as today's management challenge. Further stating that today's talented professionals are highly sought after yet have increased opportunities in choosing the most appealing work environment.

Figure 5: Industry Business Challenges



(Rethinking Construction 2000)

5.2.9 Shared Ownership

People are (generally) more committed to plans and activities 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 A. 1998). Yet, on the other hand, these 'ownership cultures' can also fail, due to:

- Employees having 'initiative fatigue'.
- Even though employees are generally and 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.

5.3 Change Process

Companies who wish to become that ‘excellent’ company and experience increased competitive advantages (e.g. implementing an innovative ICT tool or ICT training evaluation program), may have to introduce a ‘culture change program / process’ that gradually ‘cultivates’ the existing culture to accept change - rather than rely on the outcomes of traditional / outdated management-led initiatives (Lewis P. and Thornhill A. 1994). However challenging or far reaching the essential results may seem, they are achievable by implementing the following ‘change activities’:

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

To follow, four change frameworks / processes identified during this investigation, which industry organisations may consider when implementing a cultural change.

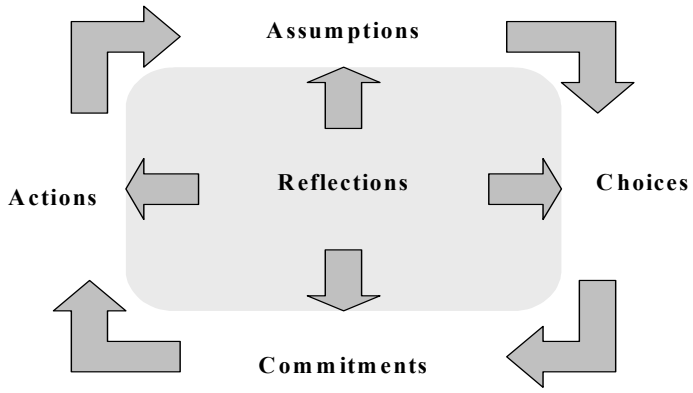
5.3.1 Change Process Model

This model enables organisations to facilitate substantial change and improved implementation via five critical activities, which inturn help ensure long-term effects (Figure 6):

- **Identifying Assumptions:** Assumptions can be considered as the ‘*taken for granted’* beliefs that individuals have about reality, which guide their actions and are to be isolated and fully understood before an organisation will advance and accept any change.
- **Analysing Choices:** This includes examining how decisions are made, who participates in the decision-making process, what criteria are used, and what consequences follow the choices made.
- **Making Commitments:** Requires choosing between two or more desirable outcomes. Leaders and their employees must then determine which of the positive outcomes they desire most and which they are willing to allocate financial and human recourses over a lengthy period.

- **Selecting Appropriate Action:** Where organisations take definite actions to help satisfy their assumptions, choices and commitments.
- **Engaging Critical Reflection:** Where organisations attempt to understand why they made certain decisions, but perhaps more importantly, how to improve upon that action.

Figure 6: Change Process Model



(Gilley J. W. and Maycunich A. 2000)

5.3.2 Force-Field Model

Based on early 1950's research into changing behaviours of individuals and social systems, (Williams A., Dobson P. et al. 1993) elaborated on a model portraying two sets of forces (driving and restraining) to help bring about change. Firstly, one is encouraged to identify the various forces impending on the change 'target' (e.g.: implementing an innovative ICT solution or process); secondly, one is encouraged to consider the relative strengths of these forces, and finally it helps one explore alternate strategies to 'modify' these forces (Table 9).

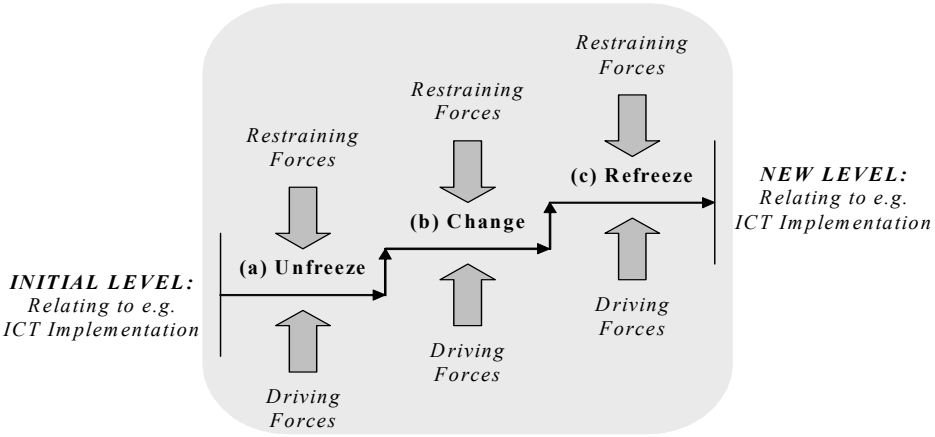
Table 9: Forces of Change

DRIVING FORCES (eg)	RESTRAINING FORCES (eg)
Change at the top	Career-based organisation
Powerful external influence	Low turnover
Powerful leader	Stable environment
Crisis or opportunity	Lack of clear authority
Acceptance of need to change	Blindness to the need to change

5.3.3 Three-Stage Model

Again based on early 1950's research and elaborated on by (Williams A., Dobson P. et al. 1993) and (Schein E. H. 1997), the Three-Stage Model (Figure 7) is yet another useful and 'revolutionary' mechanism in bringing about change in culture. Achieved by firstly, 'unfreezing' existing forces, secondly, introduce change (geared to re-establishing the 'equilibrium of forces') and finally, to 'refreeze' the new situation.

Figure 7: Three-Stage Model

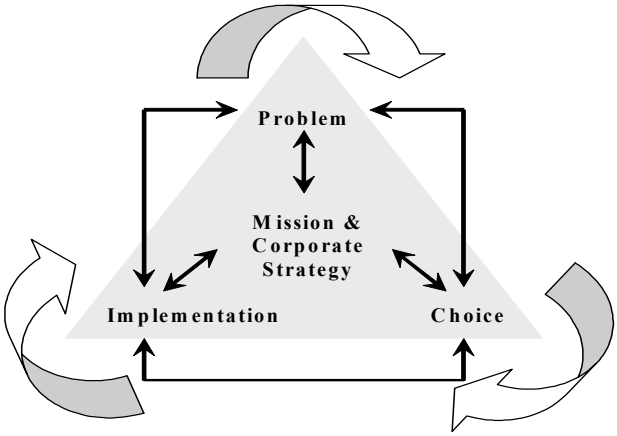


Adapted from (Williams A., Dobson P. et al. 1993) and (Schein E. H. 1997)

5.3.4 Decision-Making Model

Described as a common and rational tool, the Decision-Making Model (Figure 8) is used to encapsulate the various stages management teams go through in solving organisational problems or in developing new opportunities in a change process (Williams A., Dobson P. et al. 1993).

Figure 8: Decision Making Model



(Williams A., Dobson P. et al. 1993)

Due to their very simplicity, the above change models / processes can be applied to a wide range of applications, whether at a group, team, individual or organisational level, and highlight the importance of a number of considerations in managing change.

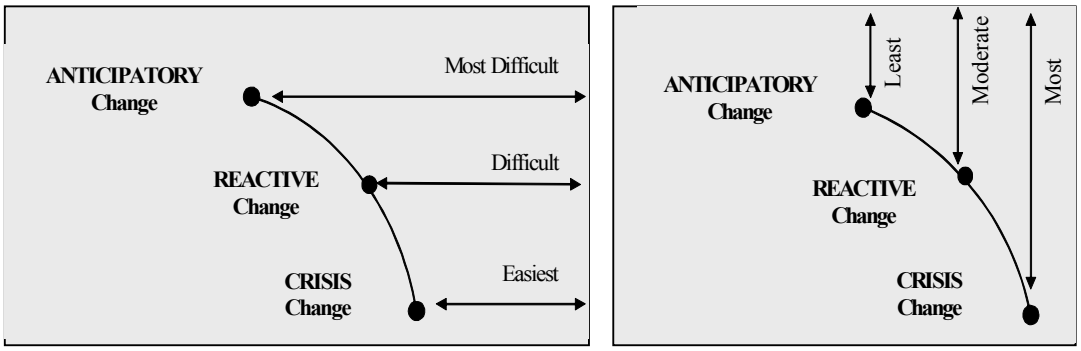
5.4 Timing

Timing and cost effectiveness of implementing a change process or method in an organisation determines the success or failure of that change. Research identifies three

types of change processes / methods (Figure 9) for consideration by AEC industry organisations:

- **Anticipatory:** When change leaders look ahead and predict change in advance – typically most difficult to implement yet most cost effective.
- **Reactive:** When change leaders react to the obvious signs and signals that change is needed
- **Crisis:** When signs and signals to change have multiplied and intensified to the point where the change leaders no longer can deny them – generally the easiest to implement but at a higher cost.

Figure 9: Difficulty vs. Cost of Change



Adapted from (Black J. S. and Gregersen H. B. 2002)

5.5 Technology Driven Change

Arguably, a wide range of technologies and e-activities, including, computers, email, Internet, Web sites, etc. dominate today's Industries, businesses and personal worlds, finding it more and more difficult to function without them. With change being the *'only thing constant in our world today'*, many industry participants are 'seduced' by these new technologies, 'blinding' them from being focused on the real reasons and need for change (Hee H. 1998). Yet, few could have predicted the massive changes and effects the introduction of these innovative technologies would have on today's industry business environment (Grenier R. and Metes G. 1995; Flanagan R. 1998)

5.5.1 Improved implementation

A major step in improving the implementation and utilisation of any ICT solution within an organisation is to firstly recognise and respect the fact that ICT developers or implementation team, senior management, and end users, are essentially sub-cultures with their own set of assumptions regarding the implementation and use of the ICT solution (Schein E. H. 1997). Considering these sub-culture assumptions is essential, especially when the success or failure of the implantation is directly dependent upon, for example, senior manager and employee satisfaction in the use of the system, and not on the type of ICT system implemented.

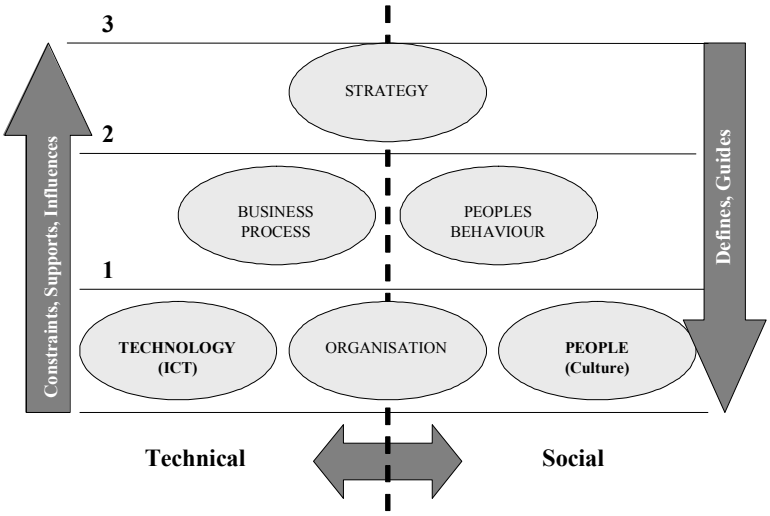
5.5.2 'Align' technology with people

The task of 'aligning' technology and people (culture) is not an easy task, and that it is important to understand the interconnections between technology and people and their

relationship with other important organisation sub-systems – i.e.: organisational structure; business and management processes; and strategy. Referring to Figure 10:

- **Level 1:** The '*infrastructure'* or '*architecture'* level contains the 'long lasting pieces' of the organisation – i.e.: organisation's technology, its structure and its people (including the set of managerial practices that regulate the relationship between the organisation and its members).
- **Level 2:** supports the system of complex activities carried out by the organisation, and include business processes and behaviours, which in turn form the capabilities of the organisation.
- **Level 3:** provides a more holistic view of the organisation's *strategy*. Strategy, in this case, refers to the way in which the organisation sees itself in relation to its stakeholders (customers, providers, shareholders, employees, government) and to the ways in which the organisation chooses to employ its resources in order to satisfy the needs of its stakeholders.

Figure 10: Organisational Performance Framework – Technical & Social Structure



(Cabrera A., Cabrera E.F. et al. 2001)

In addition to the above description of levels 1, 2 and 3, successful technological innovation and implementation requires either (a) the technology be designed to fit the 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. Further suggesting industry organisations consider the following when faced with technology driven change:

- The implementation of a new technology can unbalance an organisation and its subsystems. Therefore, successful ICT integration depends on how well the organisation and its subsystems absorb these disruptions and adapt to a 'new equilibrium'. Failing to achieve this new equilibrium will result in a waste of time and resources.
- This equilibrium must be viewed along both *vertical* and *horizontal* dimensions (Figure 10):
  - **Vertical**: refers to the alignment between the new ICT, the capabilities of the organisation, and its strategy. As there are no 'coherent universal technologies', a technological innovation would be invaluable to industry organisations, if it can contribute to generating the capabilities necessary for the organisation to achieve its objectives.
  - **Horizontal**: refers to the integration between the social and technical subsystems of the organisation. To successfully adopt a new technology, organisations have to adapt its structure and its human resource 'architecture' in a way that allows the new technology to be used by the right people in the right way and at the right times.

- Changes in the organisation's core technology will often challenge existing procedures and decision-making policies, and force the 'modification' of existing jobs and job assignments.
- The people subsystem – i.e.: the norms, values and basic assumptions shared by people within the organisation - provides a valuable medium to assess and manage technology driven change (Cabrera A., Cabrera E.F. et al. 2001).

5.5.3 Promote an 'Electronic' Culture

To ensure the successful transition from paper to electronic, the industry needs to 'crawl before it attempts to walk' the ICT road of technological change (Zipf P.J. 2000). By knowing what the problem is – i.e.: paper-based communication - and knowing what the solution is – i.e.: electronic / virtual communications - is simply not enough. Organisations need to investigate and fully understand how to transition from the one to the other. As a result, (Grenier R. and Metes G. 1995) recommend nine basic activities to help today's industry organisations design and construct a successful transition strategy:

- **Engage**: Top management launches a formal and objective process to examine the organisation's current situation and recognises that their business exists in the electronic / virtual environment.
- **Visioning**: Management collaboratively creates a vision of what the electronic / virtual future looks like and the role the organisation will play in it – then shared with the rest of the organisation.
- **Deciding**: Executive management decides and commits to the transition.
- **Consensus**: Management concentrates on getting the word out and building a consensus among the key 'influencers' in the organisation, including managers, technical specialists, hr professionals, etc.
- **Entire Organisation**: Management develops and initiates a process to introduce the concept of an electronic / virtual operation to the entire organisation, including information on the challenges, opportunities, expectations, tasks, training, etc.
- **Building a Planning and Designing Culture**: By example, training publicity, and on site leadership, management raises the organisation's awareness of the value of a planning and design approach to work.
- **Sensing Readiness**: Management examines key indicators of the organisation's readiness to gauge its current state and as a guide to select leaders.
- **Create a Prototype**: Management select two or three traditional 'weak' yet traceable areas or tasks in the organisation's performance, and then develop the specifications for a prototype project that will use electronic / virtual operations to perform similar tasks, whilst meeting aggressive business goals. The marketing, personnel, development, support, etc will need to be worked into the design of the prototype.
- **Commissioning a Project Leader**: Simultaneously, management identifies a project manager to lead the electronic / virtual team in the design of the new process and prototype - whilst ensuring the desired specifications are met, and delivery of new knowledge.

The above nine activities, are not necessarily undertaken in sequence, but rather in parallel – i.e.: an interacting and continuous process - and when undertaken with commitment by both senior management and employees, increases the probability of a successful transition throughout the organisation.

5.5.4 ICT Champion

Business success alone is insufficient for managers to justify the implementation of integrated ICT strategies, unless there is a strong support for such change from ICT champions (preferably senior management within the organisation). An, motivated only by

profit maximisation (or other desirable financial objectives) is not enough. Many firms adopt ICT tools and systems for profit-motivated reasons and fail due to underestimating– i.e.: successful ICT adoption depends on the 'politics of technology' in its management in the organisation (Tantoush T. and Clegg S. 2001).

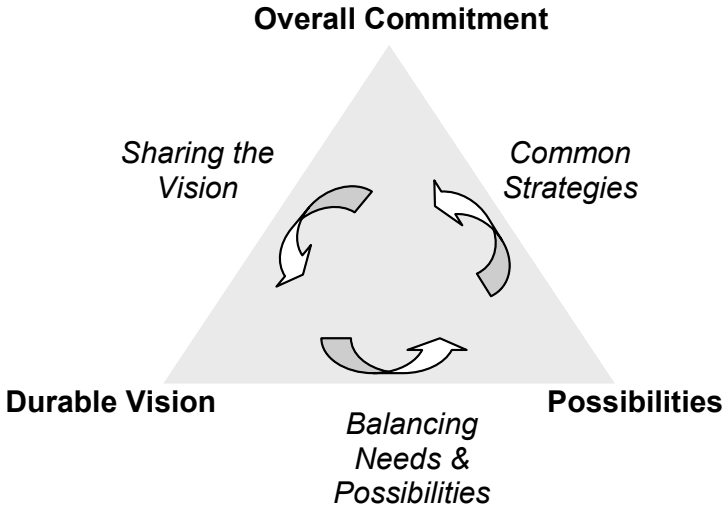
The feasibility and decision-making process of implementing a change / new ICT system within an existing organisation can be made easier by making use of the following guidelines:

- Maintain openness and honesty throughout the planning, design, development and implementation process.
- Encourage participatory planning in defining goals, objectives and in influencing the design or procurement of the new ICT system.
- Managerial support and involvement should be evident from the beginning to the end of the planning and implementation process.
- The goals for the change should be understood and viewed positively by all concerned.
- Overall benefits are to be maximised and efforts made to coordinate the goals of the new system with the existing goals of the organisation.
- There must be enough opportunities for education and training on using the new system as well as positive incentives for it.
- Both the organisation and new ICT system must be designed for the people who will use it (Paulson B.C. 1995).

5.5.5 Cornerstones of Success

Studying the implementation of innovative ICT systems, Finnish construction companies identified 'Three Cornerstones' of success and the effect they have on a project (Figure 11).

Figure 11: Three Cornerstones of Successful ICT Implementation



Adapted from (Myllymaki R. 1997)

5.5.6 ICT Implementation Strategies

Construction industry executives and management need to consider the advantages and disadvantages of the following four possible ICT implementation strategies, and select the one that best serves the needs of the application and its users:

- **Total conversion at a fixed date**: The use of the old (existing) ICT system is stopped and the new one is started or put in its place, on a fixed date. This has the advantage of being less stressful and trained users are ready to start immediately. The disadvantage is that if the implementation is poorly planned or the system is faulty, users may be demoralised.
- **Parallel operations with a gradual transition**: This strategy may be appropriate for a new and unproved ICT system. The advantage is that one can check the new results against the old to ensure that all is going well. The disadvantage is that double the effort is required in running both systems simultaneously and users may stall as long as possible to avoid learning the new system.
- **Phased implementation**: This allows separate modules to be added, over time, and eventually make up an integrated system. The advantage is that training and implementation workload can be distributed over a period where corrections and adjustments can be made. The disadvantage is the possibilities of difficulties when 'bridging' incompatibilities between the components of the old and new systems.
- **Pilot implementation**: This is when change leaders introduce the new system on a project that has interested and capable personnel, who have the motivation and initiative to try to make it succeed. The advantage is that two or more alternative packages can be tested concurrently and even if one of the pilot tests fail, or found to be unsatisfactory, the 'damage' is confined to one site. The disadvantage is that it is not suitable for centralised systems (Paulson B.C. 1995).

5.5.7 Overcome fear

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.:

- 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 innovative solutions (CRISP 2000).

5.5.8 True Nature of Change

It is also important for implementers 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 employees and the company. This ‘clouded’ employee ‘programming’ is the grounds of resistance towards technological change (Hughes T., Williams T. et al. 2000). Middle managers, for example, 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 employees and even senior management due to lack of knowledge, awareness or understanding (Kaarst-Brown M.L. and Robey D. 1999).

5.5.9 Improve benefits

To increase and strengthen the process of realising ICT adoption benefits, (Fujitsu Centre 1998) recommend:

- **Increasing awareness of, and skills to implement ICT–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 on capturing the benefits of ICT 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 ICT benefits by:**
  - commissioning an international comparative study of the impact of regulatory frameworks and effective inter-organisational ICT systems on industry structures; and
  - develop tender guidelines for Commonwealth and State Government projects that encourage ICT-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 ICT use in the industry by:**
  - establishing industry-wide awards for ICT best practice;
  - supporting industry forums on the advantages of using ICT for value-added as apposed to cost-minimising ICT strategies; and
  - researching the contribution of regulatory changes to the adoption of ICT-based value added strategies by the industry.

In support of the above, (Mitropoulos P. and Tatum C.B. 2000) suggest the following 'actions' are to be taken by its participants to increase the rate of technological adoption within the construction industry:

- **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.

5.6 Training and Education

Construction industry organisations need to 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). The necessity to recognise the culture of an

organisation and its effect on training (and its evaluation) is essential. Trainers are recommended to consider the following 'action points' to help address this issue (Lewis P. and Thornhill A. 1994):

- firstly, attempt to understand the organisation's culture and organisational attitudes to training evaluation;
- 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) Forces of Resistance (Section 5.3.2) to help 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 culture change attempt.

Furthermore, to ensure efficient and continued use of, for example, a new ICT system, trainers need to consider the possible negative effects associated with training potential end users, including:

- 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 M.H. 1999).

There is also an equally significant role for tertiary education to further develop and support the understanding of how to evaluate and implement technological and cultural 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). Training can be offered through, for example, innovative synchronised and instructor-led training systems with video, audio and graphical presentations, allowing fuller learning participation from any location. Furthermore, it is predicted that higher quality online training and courseware (meeting the ever-broadening needs of industry learners and organisations) will become, and in many cases already is, a standard method of training, thereby altering the adult learning experience in future decades (Kilby T. 2001).

5.7 Summary

Change has always been and remains difficult, and when attempts are made to changing culture, it is inevitably a slow process, where the all too common phrase "*you can't change culture overnight*" becomes a major excuse for not changing culture at all. Research defines culture as being '*complex'*, '*multi-levelled*' and '*deeply rooted*,*'* a concept that must be observed and analysed at its every level before it can be fully understood or successfully changed and managed. In many cases organisations have attempted to change their culture, and employees only learn the basics of this 'new' culture without fundamentally altering their 'old' culture (beliefs, values, and attitudes, etc). Organisations will change only as far and as fast as its collective individuals are willing to change, because people are and always will be 'instinctively programmed' to resist any change. Therefore, to change any organisation strategically and successfully, research recommends one must first attempt to change the

individual beliefs, attitudes and values (culture) within the organisation before the organisation as a whole can benefit.

The industry has to realise the cost of delaying any technologically driven changes is in many cases not only inconvenient, but often, catastrophic. When the implementation of a new ICT solution or process, for example, drives the change in an organisation's culture, organisation leaders have to realise from the outset that hierarchical imposed solutions usually do not work well when sub-cultural differences and conflicting assumptions are involved. Instead, new intercultural processes are to be developed, permitting better communication between the sub-groups, and allowing the strengths of each to interact to form an integrative and new implementation solution. If this process is not undertaken and managed correctly, then the old (traditional) and new (ICT) practices will only superficially and temporarily co-exist, resulting in the organisation's original '*way of doing* things' to eventually resurface.

Although considered 'background literature' to an on-going and in-depth PhD investigation into AEC industry specific organisations and project team member values, attitudes and beliefs, etc. towards a technology driven culture change, 2001-008-C researchers believe lessons learnt from other industry sectors is essential to moving towards a culture change philosophy. The 24 general 'Culture Change Guidelines' is therefore the first of many phases in developing a set of AEC industry specific 'Culture Change Guidelines' that will assist industry stakeholders in transforming their deeply embedded and resistive nature to technologically driven change, and help transform it into a more 'technology adoptive', flexible and continuously evolving culture.

6 CONCLUSION

Research indicates that in this uncertain and ever changing world, the construction 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. 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.

Furthermore, culture inevitably is difficult to change and manage, as it essentially represents the accumulative beliefs, attitudes and values that individuals within an organisation, group or team possess, which must ultimately be changed if the overall culture is to be changed. Leaders of a change process need to realise that most changes within an organisation will usually cause and expect some change in its existing culture and sub-cultures – i.e.: change in certain values, attitudes, assumptions, and behaviours, etc. Therefore, having a better understanding of the effects change has on the sub-cultures of an organisation, group or team, will inturn help leaders of a change process better understand the resistance towards the change itself, and provide a more realistic approach on how to manage it.

Continued efforts in identifying ways to overcome the construction industry's resistance to change by promoting research and industry recommended guidelines to help modify traditional work habits and improve current technical limitations; and encourage the use of innovative ICT and Internet-based solutions, will undoubtedly help increase the overall knowledge, awareness and skills, of all industry stakeholders. This will result in a major social and technological impact that will integrate the construction industry in a unique, distinctive, and never before experienced way.

7 BIBLIOGRAPHY

Anumba C.J. and Ruikar K. (2002). "Electronic Commerce in Construction: Trends and Prospects." Automation in Construction **11**.

Baines A. (1998). "Creating a Culture of Ownership." Work Study **47**(1).

Bate P. (1996). Strategies for Cultural Change. Oxford, Butterworth Heinemann.

Black J. S. and Gregersen H. B. (2002). Leading Strategic Change: Breaking Through the Brain Barrier. New Jersey, Pearson Education Inc.

Bowden S., Thorpe S., et al. (2002). Usability Testing of Hand Held Computing on a Condtuction Site. Loughborough, UK, Hong Kong, PR China, Arup, Department of Civil and Building Engineering, Loughborough University, and Department of Building and Real Estate, Hong Kong Polytechnic University.

BRE (2002). E-tagging 2002. UK, Construction Products Association (http://www.constprod.org.uk).

Cabrera A., Cabrera E.F., et al. (2001). "The Key Role of Organisational Culture in a Multi-System View of Technology-Driven Change." International Journal of Information Management **21**(3).

CITE (2003). Making e-Business Happen. CITE Information Pack. http://www.cite.org.uk, Construction Industry Trading Electronically (CITE). **2003**.

CRISP (2000). Report on a Workshop: Technological Change and Rethinking Construction. UK, Prepared by Lorch Associates for the Construction Research and Innovation Strategy Panel (CRISP) Commission.

DCITA (1998). Where to go? How To Get There? Canberra, Australia, Commonwealth Department of Communications, Information Technology and the Arts (DCITA).

Ecommerce, D. (2002). Dr. Ecommerce: Answers Your e-Questions (http://europa.eu.int/ISPO/ecommerce/drecommerce/index.html). **2002**.

Electronic Transactions Act (2001). Electronic Transactions Act No: 162 of 1999. Canberra, Office of Legislative Drafting, Attorney General's Department.

Flanagan R. (1998). Creating Competitive Advantage In Construction With Technology. Second International Conference on Construction Project Management, Critical Issues and Challenges Into The Next Millennium (February 19-20), Raffles City Convention Centre, Singapore.

Foresight (2000). Constructing the Future: Making the Future Work For You. UK, Foresight, Built Environment and Transport Panel, Construction Associate Programme.

Fujitsu Centre (1998). Information Technology in the Building and Construction Industry: Current Status and Future Directions. Australia, Prepared by Fujitsu Centre, Australian Graduate School of Management & Building Research Centre Faculty of the Built Environment, University of New South Wales, for the National Building & Construction Committee, Department of Industry, Science & Tourism (DIST).

Gilley J. W. and Maycunich A. (2000). Beyond the Learning Organization. New York, Perseus Books.

Grenier R. and Metes G. (1995). Going Virtual: Moving Your Organisation into the 21st Century, Prentice Hall Inc.

Hardy E. (2003). Six Hot Technologies That Could Profoundly Change Handhelds, http://www.brighthand.com/.

Hardy E. (2003b). Three More Upcoming Technologies That Could Profoundly Change Handhelds, http://www.brighthand.com/.

Harty C. (2003). The Re-Organising of Construction Design Information Technologies and Coordination in Construction Practice. Construction Innovation and Global Competitveness - 10th International Symposium, USA, CRC Press.

Hee H. (1998). Information Technology & The Deployment of CAD Systems: An Enabler Or Disabler of Construction Management? A Critical Appraisal of Its Impact On Design & Build Projects In Singapore. Second International Conference on Construction Project Management, Critical Issues and Challenges Into The Next Millennium (19-20 February), Raffles City Convention Centre, Singapore.

Hensey M. (2001). Collective Excellence: Building Effective Teams. Virginia, American Society of Civil Engineers (ASCE) Press.

Hughes T., Williams T., et al. (2000). "It Is Not What You Achieve, It Is The Way You Achieve It." Total Quality Management **11**(3).

IIB (2002). e-Business & m-Commerce (www.iib.qld.gov.au/guide), Information Industries Bureau (IIB), Queensland Department of Innovation and Information Economy. **2002**.

Industry Science Resources (1999). Building For Growth: An Analysis of The Australian Building and Construction Industries. Canberra, Ausinfo.

ITCBP (2003). e-Construction, e-Procurement and e-Tendering. http://www.itcbp.org.uk/econstruction/, Information Technology Construction Best Practice (ITCBP). **2003**.

Kaarst-Brown M.L. and Robey D. (1999). "More Myth, Magic and Metaphor: Cultural Insights into the Management of Information Technology in Organizations." Information Technology & People **12**(2).

Kajewski S. and Weippert A. (2000). Online Remote Construction Management: Literature Review. Brisbane, Australia., Queensland University of Technology (QUT).

Kajewski S.L., Tilley P.A., et al. (2003). Hand-Held Technology Review (Report 2001-008-C). Brisbane, Australia., CRC for Construction Innovation (http://www.construction-innovation.info/).

Kajewski S.L. and Weippert A. (2003). A Brief Synopsis in the Use of ICT and ICPM in the Construction Industry (Report 2001-008-C-01). Brisbane, Australia., CRC for Construction Innovation (http://www.construction-innovation.info/).

Kajewski S.L. and Weippert A. (2003). Industry Culture: A Need for Change (Report 2001-008-C-05). Brisbane, Australia., CRC for Construction Innovation (http://www.construction-innovation.info/).

Kajewski S.L., Weippert A., et al. (2003). Electronic Tendering: An Industry Perspective (Report 2001-008-C-07). Brisbane, Australia., CRC for Construction Innovation (http://www.construction-innovation.info/).

Kilby T. (2001). "The Direction of Web-Based Training: a Practitioner's View." The learning Organisation **8**(5).

Lewis P. and Thornhill A. (1994). "The Evaluation of Training: An Organizational Culture Approach." Journal of European Industrial Training **18**(8).

Linowes J.G. (1999). "Invest in the Best, Communications." Journal of Management in Engineering(November/December).

Louie D. (2001). Butler of the Future, www.abcNews.com/.

Love P.E.D., Tucker S.N., et al. (1996). "Construction Process Re-engineering and The Australian Construction Industry." Australian Institute of Building Papers **7**.

Lukmani M. (2002). Survey of Software Support in the Area of Java, Operating System, Security, and Middleware for Pervasive Computing Devices. Los Angeles, Department of Electrical Engineering, University of Southern California.

Michel H.L. (1998). "The Next 25 Years: The Future of the Construction Industry Communications." Journal of Management in Engineering(September/October).

Mitropoulos P. and Tatum C.B. (2000). "Forces Driving Adoption of New Information Technologies." Journal of Construction Engineering and Management(September/October).

Morley M. and Heraty N. (1995). "The High-Performance Organisation: Developing Teamwork Where It Counts." Management Decision **33**(2).

Murray M., B. D. (2003). The Development of E-Commerce within the Global Construction Industry. Construction Innovation and Global Competitveness - 10th International Symposium, USA, CRC Press.

Myllymaki R. (1997). The Implementation of Information Systems In A Construction Company Using New Information Technologies. International Conference on Construction Process Re-engineering (July 14-15), Gold Coast, Queensland, Australia.

NSW Department of Commerce (2003). Welcome to the eTendering System Help Page. https://tenders.nsw.gov.au/commerce/shared/help.cfm?p_page=rulesoftendering&p_pagetitle =Rules%20of%20Tendering, New South Wales (NSW) Department of Commerce. **2003**.

NSW Government (1998). Information Technology In Construction - Making IT Happen,. Sydney, New South Wales (NSW) Government: Department of Public Works and Services (DPWS).

NSW Government (2001). Electronic Procurement Implementation Strategy (http://www.cpsc.nsw.gov.au/e-procurement/contents.htm). Sydney, New South Wales (NSW) Department of Public Works and Services (DPWS). **Report No 01063**.

NSW Government (2002). Electronic Procurement Implementation Strategy - Guidelines (http://www.cpsc.nsw.gov.au/e-procurement/contents.htm). Sydney, New South Wales (NSW) Department of Public Works and Services (DPWS). **Report No 02010**.

NSW Government (2003). Welcome to the eTendering System Help Page. https://tenders.nsw.gov.au/commerce/shared/help.cfm?p_page=rulesoftendering&p_pagetitle

=Rules%20of%20Tendering, New South Wales (NSW) Government Department of Commerce. **2003**.

NT Governement (2000). An Introduction to "Tenders Online", Northern Territory (NT) Governement: Department of Corporate and Information Services (DCIS) Contract and Procurement Services.

NT Government (2000). An Introduction to "Tenders Online", Northern Territory (NT) Government: Department of Corporate and Information Services (DCIS) Contract and Procurement Services.

Olesen K. and Myers M.D. (1999). "Trying to Improve Communication and Collaboration with Information Technology: An Action Research Project Which Failed." Information Technology and People **12**(4).

Paulson B.C. (1995). Computer Applications in Construction. Singapore, McGraw-Hill, Inc.

Pepper G. L. (1995). Communications in Organizations: A Cultural Approach, McGraw-Hill Inc.

Pietroforte R., C. N. (2003). E-Construction in the USA: A New Research Agenda. Construction Innovation and Global Competitveness - 10th International Symposium, USA, CRC Press.

Reboli D., Magdic A., et al. (2000). Mobile Computing in Construction. http://kamen.uni-mb.si/cgi/Mobile%20computing%20in%20construction.htm, Construction IT Center, Faculty of Civil Engineering, University of Maribor Smetanova Maribor, Slovenia.

Rethinking Construction (2000). A Commitment to People: "Our Biggest Asset". UK, Report from the Movement of Innovation's working Group on Respect for People, Rethinking Construction, Department of Trade & Industry.

Sadri G. and Lees B. (2001). "Developing Corporate Culture as a Competitive Advantage." Journal of Management Development **20**(10).

Saidi K.S., Haas C.T., et al. (2002). The Value of Handheld Computers in Construction. Austin, USA, Department of Civil Engineering, University of Texas.

Schein E. H. (1997). Organizational Culture and Leadership. San Fransisco, Jossey-Bass Inc.

Schein E. H. (1999). The Corporate Culture Survival Guide. San Fransisco, Jossey-Bass Inc.

Tantoush T. and Clegg S. (2001). "CADCAM Integration and the Practical Politics of Technological Change." Journal of Organizational Change Management **14**(1).

Technology-Watch (2003). E-tagging of Building Products - An Introduction. http://www.technology-watch.info/news.asp?NewID=17.

The Construction Confederation (2001). An Introduction to e-Business in Construction. http://www.thecc.org.uk/index.asp?page=whatsnew (Publications), The Construction Confederation. **2003**.

Thorpe T. and Mead S. (2001). "Project-Specific Wed Sites: Friend or Foe?" Journal of Construction Engineering and Management(September/October).

Vickers M.H. (1999). "Information Technology Development Methodologies - Towards a Non-Positivist, Development Paradigm." The Journal of Management Development **18**(3).

Williams A., Dobson P., et al. (1993). Changing Culture: New Organisational Approaches. London, Institute of Personal Management (IPM).

Worthington R. C. (2002). The Devil is in the Details: e-Tendering Poses Potential Legal Risk. Summit: Canada's Magazine on Public Sector Purchasing. http://www.summitconnects.com/Summit_Magazine/magazine_contents/magazine_contents.htm, The Summit Group. **Autumn**.

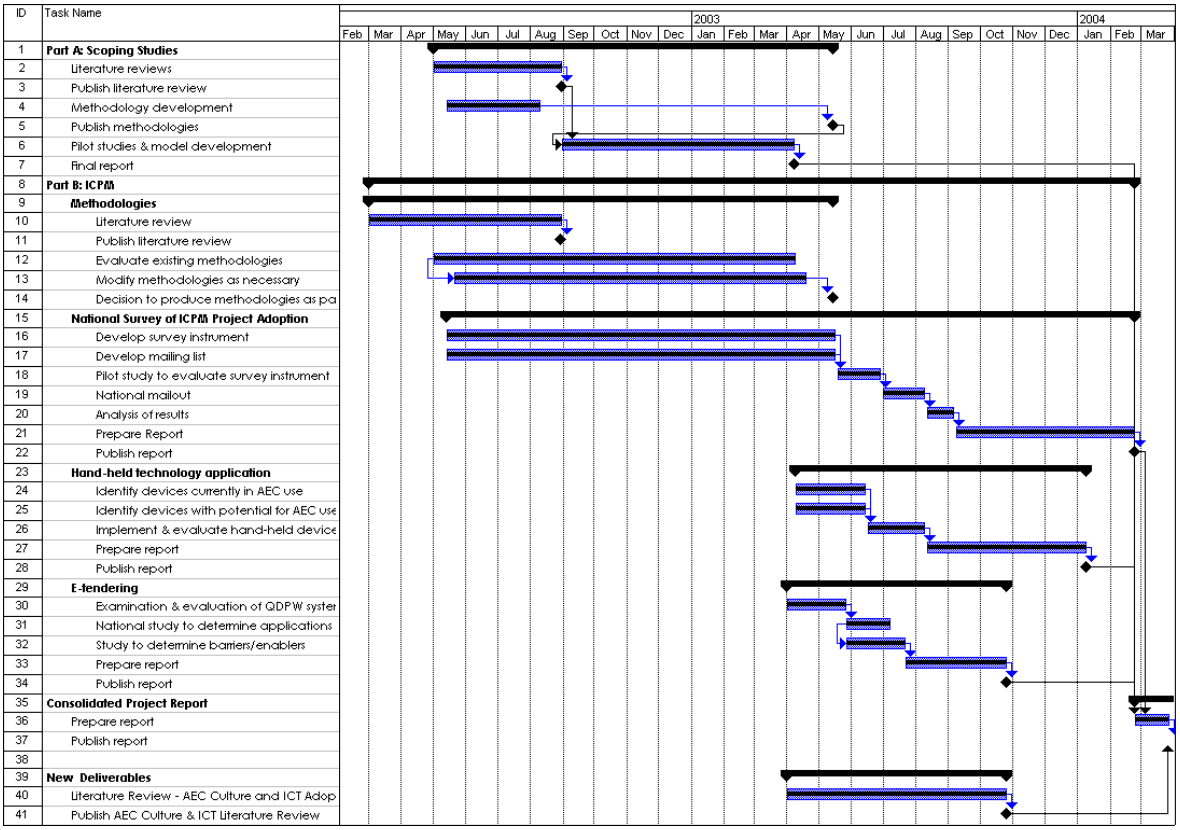
Woulds J. (1997). Information Privacy and Security - A Regulator's Priorities. Information Security Technical Report. **2**.

Zipf P.J. (2000). "Technology-Enhanced Project Management." Journal of Management in Engineering(January/February).

8 APPENDICES

Appendix I: 2001-008-C Project Schedule

Figure 12: 2001-008-C Project Schedule



Appendix II: eTender Guidelines

The following eTender recommended guidelines (a-c) are derived from **Report 2001-008-C-07** – 'Electronic Tendering: An Industry Perspective' (Kajewski S.L., Weippert A. et al. 2003) and is to be referred to for a more detailed source of information.

(a) eTender Literature Recommended Guidelines:

In an attempt to ascertain any barriers and enablers from both a technological and end-user perspective, one of the main objectives of the 2001-008-C (Part B) research project is to undertake an extensive 'general' industry wide literature review on industry and Government current state-of-play pertaining to e-Tendering. From this investigation, researchers identified a number of eTender recommended guidelines (Table 10).

Table 10: eTender Literature Recommended Guidelines

ETENDER LITERATURE REVIEW INVESTIGATION		
#	**OUTLINE**	**RECOMMENDATION**
ETL1	**eTender Basic Features:** Research identified a number of e-Tender system recommendations in relation to its basic features, functionality and capabilities:	**1)** Distribute all tender documentation via a secure web-based tender system – thereby avoiding the need for collating paperwork and couriers. **2)** The client/purchaser should be able to upload a notice and/or invitation to tender onto the system. **3)** Notifications are sent out electronically (usually via email) for suppliers to download the information and return their responses electronically (online). **4)** Updates and queries are exchanged through the same e-Tender system during the tender period, **5)** The client/purchaser should only be able to access the tenders after the deadline has passed. **6)** Hold all tender related information in a central database, which should be easily searchable and fully audited, with all activities recorded. **7)** It is essential that no tender documents can be read or submitted by unauthorised parties. **8)** Users of the e-Tender system are to be properly identified and registered via controlled access. In simple terms, security has to be as good as if not better than a manual tender process. Data is to be encrypted and users authenticated by means such as digital signatures, electronic certificates or smartcards. **9)** Assure all parties that no 'undetected' alterations can be made to any tender. **10)** The tenderer should be able to amend the bid right up to the deadline – whilst the client/purchaser cannot obtain access until the submission deadline has passed. **11)** The e-Tender system may also include features such as a database of service providers with spreadsheet-based pricing schedules, which can make it easier for a potential tenderer to electronically prepare and analyse a tender.
ETL2	**eTender Risks:** When industry professionals choose an e-Tender process or system, the potential risks in using such a system or process are directly	**1)** Where tender information is simply posted on the internet as 'pure information'. ***Recommendation 1:*** *Although exposed to minimum levels of risk, attention must be given to its contents – that is, truth, accuracy, not misleading or defamatory, etc.* **2)** Where the e-Tender web site claims to have tender related information that tenderers need to rely on and perhaps download.

	proportional to the increasing levels of electronic interaction:	***Recommendation 2:*** *In this case, owners or managers of the e-Tender system are to spend more time ensuring that what is on their site is complete, accurate and true. The inclusion of a 'non-reliance' exclusion clause may also be necessary. Ensure the tender documentation can in fact be successfully downloaded (in its entirety), especially if tenderers are asked to reply in hard copy format.* **3)** This is at the top end of the 'risk scale', having a fully interactive internet-based e-Tender system, where tenderers both receive an invitation to tender, and reply with a tender bid electronically – that is, with no option of obtaining a paper copy of the tender documentation (except by printing out the contents of the web site). ***Recommendation 3:*** *In this case, security of information and integrity of the e-Tender system is of paramount importance. Here, legally binding and enforceable contracts are being formed electronically, leaving little room for error in receiving, sending, or storing the information. Furthermore, as owners or managers of the e-Tender system, they are unable to simply exclude all liability for what could happen during an electronic e-Tender process, and will likely have to assume some of the unforeseen risks (especially when an electronic reply is the only option)* (Worthington R. C. 2002).
ETL3	**Improved eTender Training & Education**	**1)** In an attempt to help increase today's construction industry participant's uptake of innovative technologies, systems and processes (such as e-Tendering), it is strongly recommended that construction organisations become learning organisations. **2)** Due to the increasing 'electronic integration' of construction processes, industry participants have no choice but to acquire themselves a complete range of new skill sets, and to 're-think' the way current construction education is organised in delivering these skills, thereby implying a need for 'cross-disciplinary education' (Foresight 2000) **3)** There is also a significant role for tertiary education to develop and support the understanding of how to accept, 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 (CRISP 2000).
ETL4	**Improved eTender Implementation:** Research identifies a number of basic recommendations when it comes to the implementation	**1)** ***Having an extremely robust and secure e-Tender system*** – by having an enhanced security policy in place and by carrying out regular security "health checks" on the system itself and its users **2)** ***Ensuring confidential information cannot get into the wrong hands*** – for instance: – Whilst many aspects of an e-Tender process are similar to traditional tender arrangements, there are certain legal issues (possibly contractually binding issues) that need special consideration -

	of an e-Tender system, including:	for instance, people often let work colleagues check their email inbox, allowing 'unrestricted' access to dedicated e-Tender system usernames and passwords. **3)** ***Clarification of certain 'grey areas' regarding timing of electronic tender documents*** – That is, the need for an e-Tender system to automatically generated and archive dispatch and receipt times of electronically distributed/submitted tender documents. **4)** ***Providing accesses to advanced capabilities within the system*** - for instance: – Allowing one to compare data from project to project in order to view relative prices and timely decision-making. **5)** ***Allowing the reuse of standard information of regular tenderers*** - for instance: – Storing the pre-qualification documents and information of a regular pool of tenderers. **6)** ***Tender terms, conditions, application forms, and software installation procedures (if applicable) are to be uncomplicated*** – to help 'persuade' certain contractors, consultants, suppliers, etc. to participate in an e-Tendering process. **7)** ***Additional e-Tender implementation issues require consideration*** including: – liability for lost or corrupted data; – ensuring that the servers are well protected – that is, having 'fallback' plans/procedures in place for when the e-Tender service were unavailable (off-line); – ensuring that firewalls do not restrict the dissemination of supporting tender related documentation (ITCBP 2003).
ETL5	**eTender Legal Issues**	**1)** The successful implementation of an e-Tendering process within the industry, for example, is **susceptible to the current legal status** regarding electronic transmissions, use of electronic signatures, etc. **2)** **Commitment by both government and industry sectors** is required to help develop more innovative strategies to build a stronger and more competitive construction industry. **3)** **Ongoing legal investigations**, aimed at strengthening organisational and individual use of electronic communications on projects must continue, by 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).

(b) eTender End-user Recommended Guidelines:

In an attempt to better understand, validate, clarify, and illustrate the meaning and step-by-step development of particular end-user *e-Tender* adoption trends, events, barriers, and perceptions ('who, 'how', 'why', 'what' and 'when'), researchers questioned a number of prequalification contractors and consultants (PQC) who used Project Services' *eTender* system. The following recommended eTender end-user guidelines (Table 11) are derived from 'end-user' responses to the questionnaire (Appendix III) and are to be referred to when developing/implementing/assessing a similar eTender system.

Table 11: eTender End-user Recommended Guidelines

ETENDER END-USER INVESTIGATION		
#	**OUTLINE**	**RECOMMENDATION**
ETE1	**eTender Web Page**: From an end-users perspective, an eTender Web page needs to:	**1)** Be professionally developed and displayed. **2)** Be presented in a logical, clear and easy to use (user-friendly) format. **3)** Have an effective yet easy to use username and password access protocol in place. **4)** Remain unchanged – where system administrators are to limit changing the setup / format of the Web page. **5)** Have the ability to review all tender documents on the eTender Web page before actually submitting them – limiting the chance of attaching incorrect documents, etc
ETE2	**eTender Process / System:** From an end-users perspective, an eTender process/system should:	**1)** 'Suit' most small, medium and large projects / construction companies; and large to medium trades – thereby increasing end-user knowledge and awareness of an electronic tender submission process, as well as increase overall industry market awareness, experience and business opportunities. **2)** Ensure eTender administrators take into account that smaller projects (e.g. minor works refurbishing and alterations), usually undertaken by smaller contractors and trades (i.e.: with limited ICT infrastructures in place), may typically not best be suited for an electronic tender process. **3)** Be 'flexible' - designed on a project-to-project and region-to-region basis. **4)** Allow end-users to submit a tender electronically and at the last minute (timing and accuracy of the system) allowing tenderers to 'hold out' for subcontractors to submit last minute prices/quotes. **5)** Allow end-users to receive all tender documents and Addendums electronically - then 'seamlessly' have the capability to forward (e.g. via email) relevant documents to printers, suppliers and subcontractors. **6)** Convincingly reduce the need, cost and time spent in having to print, bind, and courier tender documents. **7)** Effortlessly, professionally and securely manage and record all Tender documents and Addendums within the system. **8)** 'Persuade' trades / subcontractors to upgrade their existing and/or invest in new hardware and software to take advantage of an eTender process.

		9) 'Encourage' the introduction of Broadband - upgrading existing phone systems to an Asymmetric Digital Subscriber Line (ADSL), thereby dramatically decreasing download time of tender documents.
ETE3	**eTender Legal Issues**: To help overcome any 'perceived' legal issues associated with using electronic methods of tendering (in relation to authenticity; integrity; and confidentiality/security) end-users believe:	**1)** eTender process/system administrators need to ensure appropriate legal policies and processes are developed and put in place to help deal with certain 'extenuating circumstances' pertaining to the electronic submission of final tenders. – That is - preventative and/or responsive actions that will be taken, for example, when an end user's own Internet Server fails, preventing a tender being submitted on time. – In this case, risks can effectively be reduced by, for example, undertaking regular backups of the eTender system and by having backup servers in place.
ETE4	**eTender Training & Education:** From an end-users perspective:	**1)** eTender administrators are to provide professional and customised (based on the various 'mindsets' of its users) hands-on training and limitless telephone assistance.

(c) eTender Technical Recommended Guidelines:

As part of the Project Services' *eTender* system investigation, researchers interviewed members of the *eTender* system*'s* technical staff, in an attempt to better understand, validate, clarify, and illustrate the system's functionality and capabilities, both from a technical and end-user perspective. The following recommended eTender technical guidelines (Table 12) are derived from this investigation (Appendix IV) and are to be referred to when developing/implementing a similar eTender system.

Table 12: eTender Technical Recommended Guidelines

ETENDER TECHNICAL INVESTIGATION		
#	**OUTLINE**	**RECOMMENDATION**
ETT1	**General**	**1)** Each consulting or contracting firm is to be a eTender system member - registered in a central database **2)** Users are to have a unique username and password to confirm their eligibility to participate in the eTender system **3)** Each Tender has to have a Tender Project Manager (TPM) who manages the Tender process including initially deciding which firms - registered in the central database - are invited to tender : – *Select Tenders* – open only to selected tenderers, and – *Open Tenders* – open to any tenderers on the central database. **4)** eTender users are to retain the option of submitting a hard copy (i.e.: paper based) **5)** Where deemed necessary and appropriate, eTender administrators can still undertake a number hard copy only tenders.
ETT2	**Security**	**1)** There is to be a nominated, continuing, primary e-mail contact within each firm on the central database – to which other e-mail contacts can be added or specified by the firm. – However, as an eTender system security precaution, whenever a secondary user within a firm is detected accessing eTender information, the system routinely must notify the primary e-mail contact also. **2)** Each eTender system password is to be specific for that Tender and “one-off” for an individual firm. – Thus if staff leave the firm and take knowledge of passwords, etc. the current password cannot be used to access information on further future tenders. – Furthermore, a tenderer’s password only remains current until the date that the tender closes. **3)** Whilst a Tender remains open, if an e-mail regarding the Tender is sent to a nominated e-mail contact and it “bounces” (that is, the e-mail is returned with addressee unknown), then the TPM for that Tender should fax or telephone the intended recipient and then make corrections to the e-mail address if it is in fact incorrect.

		4) For audit trail purposes, normal logging of all user access to an eTender Web-server must be available for perusal should it be necessary. It is further advised that a standard level of back-up procedures for eTender documents are in place, with routine archiving taking place after two years of on-line storage. **5)** Once the eTender period closes and following evaluation by a Selection Panel and formal tender approval, the TPM should send out (a pre agreed number) of hardcopy plus one electronic copy (on CD) of the full documentation to the successful tenderer. **6)** To verify the Tender - a 'letter of acceptance' is to be signed. **7)** The contract becomes valid when the hardcopy of the contract has been signed. **8)** To ensure minimal downtime should one server fail or 'crash' for any reason, the eTender system can be housed on "dual, mirrored server" hardware - based upon Microsoft software. – An eTender system can utilise, for example, Microsoft's IIS (Internet Information Services) Web-server, SQLServer database software, and the ASP (Active Server Pages) approach to Web-serving. **Note:** Microsoft's IIS software is used as the QDPW Project Services eTender Web-server software, since QDPW Project Services is, for the most part, a 'Microsoft shop', and maintains substantial expertise in various Microsoft products in addition to IIS.

ETT3	**Network**	**1)** eTender systems can utilise commercialised ICT service providers (e.g.: CITEC[3]) as their Internet service and network provider. **2)** eTender system administrators are to ensure tenders released via an eTender system do not cause any problems or bottlenecks at peak tender submission times. – It should be borne in mind that users can also lodge additional documents as well as the Tender Form – The size of these accompanying attachments could have some influence on the speed of uploading information from the tenderers to the eTender system (thus a *potential* problem for users). **3)** It should be noted that *if* the eTender system is unavailable for some reason at a key period in the Tender process, it is within each TPM's capacity (after consultation with his manager) to grant an extension to the Tender time to take account of the system unavailability. – The Electronic Tender Form is to be reasonably straightforward, – Therefore, should interruptions to transmission occur while the Form is being completed, then the user could re-key the tender details again if the system is unable recover the partial information.
ETT4	**Document Management**	**1)** Architectural drawings and detailed Computer Aided Drafting (CAD) plans necessary to supplement the textual information for a Tender, are to be converted to suitable files (e.g. .tif) by the eTender service group. – These files are then to be returned to the relevant TPM to lodge on the eTender Web site - along with any other documents that then comprise a complete package of Tender documentation. **2)** At this stage of eTender implementation, e-mail (or fax, or telephone call) is to be used to formally communicate with the eTender customers (not SMS messages, etc.). **3)** Under advice from relevant legal and contractual groups, eTender administrators is to confirm and operate on the principle that the information held on an eTender Web-site is the definitive set of documentation for each Tender. – Therefore, should the information be altered or corrupted - by potential users or factors in the downloading process - then eTender administrators cannot be held responsible. **4)** If alterations to the Tender are found necessary, then the original eTender document version is not to be amended:

[3] *CITEC is a national Information and Communications Technology (ICT) service provider that, as a fully commercialised business of the Queensland Government, services both government and private business clients.*

		– Rather an Addendum or full (amended) document is to be reissued. – Users are to be formally notified of the issue of such an Addendum, and – Asked to acknowledge (in the Electronic Tender Form) the receipt of any such Addendum.
ETT5	**People**	**1)** Research reveals a fast-growing acceptance of eTender systems. – Majority of users seem to be larger companies with an adequate level of expertise in the use of ICT already within their business. **2)** On-line "help files", "tutorials" and "start-up guides" for an eTender system are to be, for example, HTML-based, thus allowing it to be viewed and navigated by most common Web-browser software such as Microsoft Internet Explorer and Netscape Navigator. **3)** To support their own staff, eTender administrators are to maintain a "Help Desk" staffed by Information Technology (IT) department/specialists during normal office hours: – This is used to log and assist simple queries from eTender clients, while queries that are more complex are logged by IT department/specialists but passed across to eTender personnel to deal with. **4)** The TPM responsible for each Tender is to be made available (by e-mail or telephone) to assist users with specific queries regarding his/her Tender. **5)** As a policy, the responsible TPM cannot view the completed electronic Tender Forms until after the closing time and date for the Tender. – This is ideally around 2pm, allowing TPMs to initiate the formal 'paperwork' or Tender Evaluation Form for the Selection Panel before the close of business the same day.
ETT6	**Moving Forward**	**1)** eTender system advantages over the traditional paper-based approach hinge on the ease with which a Tender Project's plans, drawings, specifications, schedules, etc. can be made widely available. – Consequently, any qualified contracting firm can download and view the "information package" of Tender documents at any convenient time, as well as having the option of subsequently lodging the firm's response to the Tender easily and electronically (with or without adding any accompanying response documents). **2)** An eTender system's levels of security and availability / reliability are to be in line with commercial expectations. – The development of, for example, a whole-of-government electronic marketplace system (based largely on an eTender 'engine') should also ensure that sufficient IT resources are made available to promote rapid on-going development and deployment. – However, this should not be at the expense of any eTender system requirements that may be thought essential for its rapid uptake - specifically within the building and construction

		industry. **3)** As an eTender system becomes more widely used and its accessibility permeates through to the smaller building and construction firms, administrators need to: – Be confident in dealing with issues relating to the education and training of potential eTender users – Provide technical assistance – Where deemed necessary, let commercial entrepreneurs take up the training and assistance opportunity. **4)** Having commercialised ICT service providers (such as CITEC) acting as an intermediary between an eTender system and the end-user, *may* cause some danger of the system development being focussed on larger users who have good network connections in place. **5)** Finally, it is essential to further assess whether smaller firms (with less IT resources or in-house skills), plus those in more "remote areas" that are less well served by high-speed Internet access, are able to use an eTender system to their complete satisfaction.

Appendix III: eTender System Qualitative Questionnaire

QUALITATIVE QUESTIONNAIRE

Queensland Department of Public Works & Project Services (QDPW/PS) eTender System

*PLEASE NOTE: contact and prequalification details will **NOT** be disclosed and the information collected from this questionnaire will remain **CONFIDENTIAL** (at the individual response level) with only summarised findings and analysis used for public distribution.*

NAMES : Confidential

POSITIONS : Principal, Estimator, Two Directors, State Manager & Assistant Manager

ORGANISATIONS : Two Contractors and four Consultants

1. WEB PAGE

(a) What is your overall impression of the eTender Web page – i.e.: format, functionality, ease of use, help function, support desk, etc?

The overall impression of the eTender Web page was mostly positive, with its users describing it as:

- Professional.
- Logical, clear and well explained.
- Basic, straightforward and easy to use.

One of the respondents stated, "*The need for a user-friendly system was identified and created*" by Project Services.

(b) Recommendations for improving the eTender Web page.

There were only three minor recommendations put forward on how to improve the e-Tender systems Web page.

- The first being the existing password access / process could be simplified and more user friendly.
- The second recommendation was that seeing "*simplicity and ease of use is the key*" in an e-Tender process, system administrators are to limit changing the set-up / format of the Web page.
- Lastly, end-users recommend including the ability to review their attached tender documents on the web page before actually submitting them – limiting the chance of attaching incorrect documents, etc.

2. SUCCESSES

(a) What has gone well with the use of the eTender system?

Since its inception, almost two years ago, there have been a number of positive experiences recorded when using the eTender system, including:

- Increased knowledge using an eTender process.
- New users have already been successful in winning a number of projects for themselves.
- The ability to submit a tender electronically and at the last minute – timing and accuracy of the system allows tenderers to 'hold out' for subcontractors to submit last minute prices/quotes.
- The ability to receive all tender documents and Addendums electronically - then 'seamlessly' being able to forward (e.g. via email) relevant documents to printers, suppliers and subcontractors.
- Reducing the need, cost and time spent in having to print, bind, and courier tender documents.
- Tender documents and Addendums are also professionally and securely managed, and recorded within the system.

(b) Has use of the eTender system improved overall efficiency on your project? (Yes / no) In what way?

One respondent stated that in some ways the eTender system has slowed down the process of information transfer (eg extra time required to first have to access the eTender system in order to download documents - instead of directly emailed documents). Yet, the majority of respondents agree - using the eTender system improved efficiencies, not necessarily on their individual projects themselves, but definitely on the overall tendering process (see previous response).

(c) Has the use of the eTender system improved the overall tender process (compared to traditional / paper-based methods) – i.e.: re information / documentation transfer, etc? (Yes / no) In what way?

Users of the eTender system mostly agree that when compared to the traditional / paper-based method, tendering electronically has definitely improved the overall tender process, stating:

- The overall process is faster and more efficient.
- The risk of missing deadlines, etc. decreased.
- The secure transmittal process of the eTender system limits the potential loss of documents.
- Mail out costs of hard copies to other trades / subcontractors has reduced because they are now able to email the relevant documents to them.
- Where trades / subcontractors are not able to receive emailed documents (due to limited ICT and Internet infrastructures), contractors and consultants can still send them the documents electronically via CD's in lieu of hard copies. Yet, it was mentioned that a large portion of documents still need to be printed out due to many of the trades and subcontractors '*are yet to catch up with the technology*'.

(d) What potential improvements (if any) do you perceive result from using an e-Tender process – e.g.: modification / upgrading of existing information and communication technology tools, systems, processes, hardware, software, etc?

Perceived improvements resulting from using an eTender process included:

- Trades / subcontractors are now 'forced' to upgrade their existing and/or invest in new hardware and software to take advantage of an electronic tendering process, which inturn may create 'a gap in the market' as not all Trades / subcontractors are willing to do this due to various reasons.
- Effective use of PDF files.

3. FAILURES

(a) What issues / problems / complaints were experienced using the e-Tender system?

Issues, included:

- The need for tenderers to download eTender's '*standard information'* each time they want to tender - requesting Project Services not '*overload'* the system and to '*keep things simple and standardised'*.
- The need to improve the current eTender 'submit' process:
  - Some suggesting the eTender system should allow its users to review, change and/or delete their attachments prior to actually submitting the final tender.
  - Others suggest due to tenderers currently being able to complete (fill in) the e-tender form only towards the end of a tender (i.e.: only once they have received last minute rates, etc from their various subcontractors and suppliers), places additional '*pressure'* on those submitting the tender - potentially causing errors.
- The fact that many of the trades, subcontractors and suppliers are still unable to manage information and documentation / drawings electronically (i.e. receive, send, etc), seems to be an ongoing concern for certain eTender users – mainly due to substandard levels of ICT infrastructures in place.
- Several eTender system users found downloading of certain large files/documents took time and that '*it would have been just as easy to issue a CD*'.
- Drawings not to scale.
- eTender system users experiencing one or two initial problems when they first used the nominated eTender password, but these were quickly resolved.
- Others feel the current password system / process needs reviewing.

(b) How have the above problems been addressed?

With the introduction of Broadband and by upgrading their existing phone systems to an Asymmetric Digital Subscriber Line (ADSL), dramatically decreased downloading time of tender documents.

Several eTender users contact and record each trade, subcontractor and supplier's preferred format (paper or electronic) and method of transmitting tender documents (e.g. via email, eTender system, CD, courier, etc.). Yet, when in doubt, tenderers will simply send out both electronic and paper copies.

4. LEGAL ISSUES

How have you/your organisation overcome potential legal issues associated with using electronic as opposed to traditional methods of tendering – e.g.:

(a) **Authenticity / Evidence**: This concerns the source of the communication - does it come from the apparent author, for example, a handwritten signature?
(b) **Integrity**: Whether or not the communication received is the same as that sent - has it been altered either in transmission or in storage?
(c) **Confidentiality / Security**: Controlling the disclosure of / access to the information contained in the communication.

Several eTender users state they have no real concerns regarding legal issues when using electronic methods of tendering. Some describe themselves as being very much '*relaxed*' with it all and using it "*in good faith*". In most cases, tenderers tend to retain copies of all items sent electronically for record purposes. Where required, all documents are signed electronically (scanned hand written signatures).

Some tenderers were concerned with how certain '*extenuating circumstances*' are legally dealt with when submitting final tenders electronically – i.e. what happens when, for example, their own Internet Server fails, preventing their tender being submitted on time? According to the eTender technical team, this has not happened yet. This of course does not mean that it could not happen in future. However, due to regular backups of the eTender system and with backup servers in place, these risks are effectively reduced. Currently, tender managers, in conjunction with the eTender technical team, deal with all technical related issues that may cause delays, on a project-to-project base.

5. TRAINING

(a) What type of eTender system training have you received from the QDPW/PS – i.e.: demos, hands-on, etc.?

The hands-on training and telephone assistance, offered by Project Services, were well received by the contractors and consultants who attended these sessions.

(b) Was this sufficient for you to effectively use the eTender system? (Yes / no)

Those who received training all answered '*Yes*' to this question.

(c) If not, what type of training would you have preferred to be proficient in the effective use of the e-Tender system?

N/A – based on previous responses.

(d) Do you believe the eTender system is 'user-friendly' enough (easy, logical, intuitive, etc) for potential users to negate the need for training? (Yes / no)

Respondents all agree that there is no need for training (depending on the various '*mindsets*' of its users) and that overall, the eTender system is '*very basic*' and easy enough to use.

6. RECOMMENDATIONS

(a) What projects, organisations, etc. (size / type / etc) are <u>most suited</u> to implementing an eTender process?

The consensus was that most small, medium and large projects / construction companies; and large to medium trades suit an eTender process. One of the respondents answered this question by saying "*we have the tools, we should be using them*"

(b) What projects, organisations, etc. (size / type / etc) would you recommend are not suited to implementing an e-Tender process?

Even though the majority agreed that most projects are suited for an eTender process (refer response to previous question), some do believe that smaller projects (e.g. minor works refurbishing and alterations), aimed at smaller contractors and trades, with limited ICT infrastructures in place, are not.

(c) What should industry participants and/or the QDPW/PS do or change to more effectively use an eTender process?

Suggestions include:

- To do "*nothing*", that the eTender system is "*an effective system as it stands*".
- Increased access to electronic tenders on the eTender system will increase industry market awareness, experience and business opportunities.
- Keeping industry bodies up-to-date and informed with regard to eTender activities and successes will help fuel private industry uptake.
- The eTender process to be 'flexible' - designed on a project-to-project and region-to-region basis.
- Due to Project Services currently being perceived as using the eTender system for the transfer of tender documents only, it is suggested setting up a web site for each tender project (e.g. via Project Services' eProject system), which would contain additional information about each individual project. Providing access to, for example, a '*technical data library*', 3D models of the project (with walk-through capabilities), etc., which inturn will enable potential tenderers to gain a better understanding as to what the designers are trying to achieve, prior to submitting their final tender.

(d) Would you recommend the use of the e-Tender system on future construction projects?

Everyone recommends the use of the e-Tender system on future construction projects. One of the users responded by saying,

"*We are very happy with the eTender System and look forward to it being standard practice*".

(e) Kindly provide any additional comments, recommendations, etc. regarding the implementation, use, etc of the QDPW/PS e-Tender system.

One response recorded for this question:

"*The eTender system was a delight to use*" and that **"*it is excellent to see the 'smart state' implementing these smart systems*".**

Appendix IV: eTender Technical Issues for Elaboration

As background information, the research team circulated the following issues of interest prior to discussions with eTender / QDPW staff.

The following discussion points were designed to elicit some background information on the ***technical issues*** surrounding the use of e-Tender-type approaches in the A/E/C industry.

It is not within the scope of these points to ascertain whether or not the current system addresses legislative requirements as may be embodied in an "Electronic Transactions Act" addressing paper vs. electronic transactions, and covering legal aspects such as:

- 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

However, issues such as the Authenticity, Integrity, and Confidentiality of information and communications may be raised from a technical viewpoint.

THE SUPPLIER'S (IE QDPW) VIEWPOINT

Security:

- security of documents in system / on server?
- of tender data submitted to system / server?
- back-up systems on critical dates e.g. submission deadlines.
- authenticity concerning 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.

Network Issues:

- requirements for adequate network bandwidth
- any likely/actual bottlenecks in accessing data during peak loads?
- critical need for reliability of system
- robust – any network problems at tender submission time?
- audit trails - tracking source of any problem (theirs or ours?)

Document Management:

- tender list
- automatically generated, or manual?
- control of logon and permissions
- pre-qualification list
- automatically generated, or manual?
- logon control and permissions
- project document management
- placement of documents on system; appropriate formats?

- placement of authorised revisions to documents?
- checking access to documents and any revisions

All these three items may have an overarching imperative in the *ease of use* in placing *source* documents on the system.

People Issues:

- develop trust in security
- develop confidence in use
- minimise user interface issues
- aid recovery from hitting wrong button
- strong emphases on ease of use
- provide access to appropriate help – online, 24 x 7 assistance?
- training & certification

THE CONTRACTOR'S (END-USER) VIEWPOINT

Security Issues:

- acknowledgement of receipt of communications
- authenticity concerning 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.

Access Issues:

Access to Documents (setting aside issues such as quality of documentation):

- Ease of access for users
- clarity of user interface
- networking constraints
- connection profiles in industry – current v. future
  (% dial-up v. ADSL v. cable broadband v. ISDN)

Access to Updates:

- Ease of access
- clarity of user interface
- explicit differentiation of update from original version
- Notification of document(s) issued
- use e-mail, or another method? (fax, SMS, etc.)
- acknowledgement of user's receipt of updates before lodgement of tender

Submission of Bid:

- Notification
- use e-mail, or another method (fax, SMS, etc.)
- acknowledgement of receipt of updates before lodgement of tender
- Security of information
- intermediate storage - when can selection panel see tender bids?
- transmission (open, or encrypted?)
- storage/archive (retained for what period after close of submissions?)
- Long-term
- compatibility between systems, and in-house electronic systems

- bottlenecks just prior submission time / aggregation of work packages (e.g. to allow head contractor to submit by 5:00 pm, all sub-contractors packages must be received by say 4:45 pm, then packages put together and total bid submitted)
- Backup systems
- take account of unforeseen localised problems such as power outages; denial of access to server; etc.

People Issues:

- develop trust in security
- develop confidence in use
- user interface issues must be paramount
- aid recovery from hitting wrong button
- strong emphases on ease of use
- provide access to appropriate help – online; 24 x 7 assistance?
- training & certification

Appendix V: Hand Held Technology Guidelines

The following Hand-Held Technology recommended guidelines (Table 13) are derived from **Report 2001-008-C-06** – 'Hand-Held Technology Review' (Kajewski S.L., Tilley P.A. et al. 2003) and is to be referred to for a more detailed source of information.

Table 13: Hand-Held Technology Recommended Guidelines

HAND-HELD TECHNOLOGY GUIDELINES		
#	**OUTLINE**	**RECOMMENDATION**
HHT1	**Selecting Suitable Handheld Devices**	When selecting a suitable Handheld device for construction applications the main things to consider include: **1)** Individuals working within a team/organisation and selection must consider the team/organisation existing frameworks and systems such as e.g. connectivity, platform interoperability. **2)** **Operating System:** Different operating systems have different characteristics and are more suited to specific tasks and customisation, including: – Task Management; – Power Management; – User Interface; – Memory Management; – Security; – Memory Protection; – Supported Processors; and – Typical Hand Held Usage. **3)** **Processor Speed:** Generally the faster the better. Specified processor speeds between devices with different operating systems may not be directly comparable i.e. some operating systems require less processing than others, and therefore, the net speed may be similar. Typical ranges are 33-200MHz for Palm OS devices and 200MHz-400MHz for Windows OS devices. **4)** **Read Only Memory (ROM):** The larger the better. Presently typical of High-end devices is 32-48MB of ROM. **5)** **Random Access Memory (RAM):** The larger the better. Need to check the required level software applications to be used. However, RAM expansion is available through add-ons. **6)** **Connectivity Options:** Need to consider the type of construction jobs i.e. Horizontal or Vertical in relation to their distance from available site/centralised network office locations or individual devices to connect. – For field workers that only require synchronisation of data at start and end of shift, USB hard wired cradle is suitable;

		– For connectivity to provide data transfer within a range of 1m and in line-of-sight then Infrared (Irda) is suitable; – For connectivity to provide data transfer and PIM synchronisation type applications within a range of 10m (100m with amplifier), Bluetooth technology is suitable; – For full network connectivity within a range of 200m, Wi-Fi is suitable. Need to consider the cost of setting up the Wi-Fi enabled server not just the individual devices; and – For full network connectivity greater than 200m (within a range limited by service only), WAN communication systems are suitable. Currently available systems include GSM (2G), CDMA (2G), GPRS (2.5G), EDGE (3G), WCDMA (3G), UMTS (3G). Cost and data download rate needs to be considered, currently slow and expensive respectively, however, they are improving exponentially. **7) Required Ruggedness:** Need to consider the type of applications and environmental conditions (dust, water) that the device is likely to be subjected. PDT and PPT devices are inherently 'ruggedised'. The traditional PDAs are able to be 'ruggedised' through add-ons. **8) Data Collection:** Automatic data collection is available through various technologies either built-in or as an add-on including: – Speech: Speech Recognition, Text to Speech and Interactive Voice Response. – Bar Code Reading; – Radio Frequency Identification (RFID); and – Finger Print Sensing Technology. **9) Add-on/Expansion Capability:** As mentioned previously the capability of a Handheld device can be greatly enhanced and/or brought to speed through the use of expansion slots. The type of slots currently available include: – Secure Digital (SD)/MultiMediaCard (MMC) slot; – Compact Flash Slot (CF)/Microdrive slot; – Springboard Slot (Handspring); – PC Slot; and – Memory Stick slot. **10) Currently available software applications** that cover construction related activities**:** The things to consider in relation to the selection of a Handheld device and the available software are how it will be accessed and what is the RAM requirements: – If it is to be accessed through a web browser (ASP or Client/Server) then the Handheld device will require Wireless Application Protocol (WAP) capabilities. – If the software is loaded on the device then the required RAM must be considered provided either as a standard inclusion or as an add-on.

HHT2	**Construction Activities / Tasks Suited To Handheld Devices**	**1)** Tasks that require access to large amounts of text information; **2)** Tasks that require viewing a small detail of a document; **3)** Tasks that require the entry of binary data; **4)** Tasks that require the entry of data into a form; and **5)** Tasks that require instant transfer of small amounts of information to and from a network (Saidi K.S., Haas C.T. et al. 2002)
HHT3	**Overcoming Screen Size, Cumbersome Data Entry & Navigation Limitations of Emerging Technologies**	To overcome these limitations: **1)** Emerging technologies such as Orientation Driven Navigation 'Near Eye' displays have and are being developed. **2)** Other emerging technologies that are looking to improve current Handheld devices include: – power sources (Fuel Cells, Photovoltaics, Micro-engines, Silver Polymer batteries) – keyboards (Virtual Laser image, Holographic), – printing (Random Movement technology), – navigation (Flexible Handhelds).
HHT4	**Future Applications**	Looking to the future: **1)** Traditional Handheld computing devices will be competing with Wearable Computers. **2)** Wearable computers provide greater potential benefit to the mobile worker through greater use of automated processes. **3)** Handheld devices of the present are a testing ground for some of the technologies slated for wearable computers in the more distant future.

Appendix VI: Culture Guidelines

In an attempt to demonstrate leadership in implementing a cultural or technological driven change within the AEC industry, 2001-008-C-05 research team members undertook an extensive 'general' industry wide literature review - **Report 2001-008-C-05** - Industry Culture: A Need for Change (Kajewski S.L. and Weippert A. 2003). From this report, researchers identified 24 'general' industry 'Culture Change Guidelines', which will assist industry stakeholders in better understanding the underlying need to transform their deeply embedded culture and resistive nature to technologically driven change into a more 'technology adoptive' culture change 'philosophy'.

Note:

The 24 'general' 'Culture Change Guidelines' (Table 14) is the first of many phases and 'background literature' to an on-going and in-depth PhD investigation into AEC industry specific organisations and project team member values, attitudes and beliefs, etc. towards a technology driven culture change. A research project that (amongst other things) intends developing a set of AEC industry specific 'Culture Change Guidelines' that will assist industry stakeholders in transforming their deeply embedded and resistive nature to technologically driven change, and help transform it into a more 'technology adoptive', flexible and continuously evolving culture.

Table 14: Culture Change Guidelines

24 GENERAL CULTURE CHANGE GUIDELINES		
#	**OUTLINE**	**RECOMMENDATION**
CC1	**Harmonise Attitudes, Values and Behaviour**	If member attitudes, values and behaviour are in harmony, then a stronger and effective culture is likely to result, where members are committed to the overall change, goals and methods of the organisation, group or team.
CC2	**Understand the 'Role' of Culture**	To make industry organisations, groups and project teams more efficient and effective, one must better understand the role that culture plays within them.
CC3	**'Culture' is Never 'Singular' Always 'Plural'**	Attempts to change the 'whole' culture of an organisation must be abandoned, because every culture is made up of a whole range of mentalities and sub-cultures, all of them different, and at different stages of development.
CC4	**Identify the Need for Change**	It is import for organisations, groups and teams to realise and create a 'need' for change, before the act of change can take place.
CC5	**Motivate People**	People are 'motivated' to change when they are confronted with real or perceived 'threats' and/or 'opportunities'.
CC6	**Suitable Change Strategy**	To ensure successful change in culture, a suitable change strategy needs to be identified and properly implemented and managed, which inturn can promote a new business strategy.
CC7	**People and Places**	People in key positions may need to be changed, moved or rotated to ensure successful change in culture within an organisation.
CC8	**People's Beliefs, Attitudes and Values**	To ensure successful change in culture, individual beliefs, attitudes and values may need to be altered by applying one or more suitable change methods.
CC9	**Structures, Systems and**	An organisation's existing communication network may entail restructuring, and require the

	Technology	implementation of an improved reward, appraisal, monitoring, budgeting and/or control systems to ensure successful change in culture.
CC10	**Corporate Image**	Promote an improved corporate image to help develop positive attitudes between both customers and staff, which inturn will enhance overall commitment towards the organisation.
CC11	**Invest in People**	To ensure successful change in culture, organisations need to improve their attitude and performance towards respecting and recruiting their people in order to retain their best talent.
CC12	**Create a Feeling of 'Shared Ownership'**	Employee participation is essential to ensure increased commitment and 'feeling of ownership' towards the implementation of a culture change process.
CC13	**Suitable Culture Change Process**	To ensure successful change in culture within an organisation, a suitable change process needs to be identified, properly implemented and managed.
CC14	**Timing of Change**	Timing and cost effectiveness of implementing a change process or method in an organisation determines the success or failure of change.
CC15	**'Align' technology with people**	Understanding the 'interconnections' between technology and people (culture) is essential during the implementation of a technologically driven culture change process. This can be achieved by (a) designing the technology to fit the organisation's current structure and culture, or by (b) reshaping the organisational structure (processes) and its culture (people) to fit the demands of the new technology.
CC16	**Promoting an 'Electronic' Culture**	Organisations need to investigate and implement a suitable 'transition strategy' to help ensure a technological driven culture change – i.e.: assisting an organisation in its transition from existing / traditional business operations and processes, to industry required (electronic) operations and processes.
CC17	**ICT Champion**	An organisation pursuing technological driven advancement or change requires strong support from an ICT champion (preferably senior management within the organisation) to undertake and lead the difficult task of managing its impact upon organisation structures and cultures.
CC18	**'Three Cornerstones' of Successfully Implementing Innovative ICT**	Industry organisations are to consider three success factors when implementing ICT: (a) **Vision:** A durable vision of the change process is required to ensure progress - shared with top management, construction managers, developers and ICT staff.

		(b) **Commitment:** Obtain overall commitment from top management, construction and ICT managers (re allocation of financial and human resources). (c) **Possibilities:** apply a 'migration strategy' that enables ICT staff to balance the ICT strategy with the companies business needs, thereby underwriting the success of the change process.
CC19	**ICT Implementation Strategies**	Construction industry executives and management need to consider various ICT implementation strategies, and select the one that best serves the needs of the application and its users.
CC20	**Overcome Fear**	The construction industry is to lesson and ultimately remove the fear of 'exploitation' of technology-led innovation.
CC21	**'Camouflaging' Change**	It is important for implementers 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 employees and the company.
CC22	**Promote ICT Adoption Benefits**	The construction industry will increase and strengthen the rate of technological adoption by promoting its benefits, developing and running short courses, establishing industry-wide awards for ICT best practice, and taking relevant action.
CC23	**Continued Training and Education - A Must**	Construction industry organisations need to become learning organisations - attuned to absorbing and using knowledge and providing for lifelong learning.
CC24	**Enhanced Tertiary Training and Education**	Tertiary education (both undergraduate and postgraduate) is to further develop and support the understanding of how to evaluate and implement technological and cultural change and innovation within construction industry organisations.

9 AUTHOR BIOGRAPHIES

Dr Stephen Kajewski
School of Construction management and Property
Queensland University of Technology
Ph +61 7 3864 2678, fax +61 7 3864 1170, email s.kajewski@qut.edu.au

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.

Mr Achim Weippert
School of Construction management and Property
Queensland University of Technology
email a.weippert@qut.edu.au

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 Associate to Dr Stephen Kajewski (Project Leader) for the Cooperative Research Centre (CRC) for Construction Innovation 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.

Mr John Crawford
CSIRO
Division of Manufacturing and Infrastructure Technology
Ph +61 3 9252 6051, fax +61 3 9252 6249, email john.crawford@csiro.au

Mr Crawford is a senior Scientist and Project Leader within the Integrated Design and Construction team at the CSIRO Division of Manufacturing and Infrastructure Technology, based at Highett, Victoria. He has been heavily involved in design research and in working with public and private industry in the innovative usage of ICT in building, construction, and engineering for many years - most recently as a team member of the Cooperative Research Centre (CRC) for Construction Innovation research project 2001-007-C: 'Managing Information Flows with Models and Virtual Environments'. He co-authored the key Technology Review for On-Line Remote Construction Management

(ORCM) report for the project - jointly supported by QUT, CSIRO and Queensland industry sponsors. In addition, Mr Crawford has been contributing to the novel CSIRO Emerging Science initiative in Tele-collaboration, and to an industry initiative in Geometric Data Exchange in the Australian Defence and Aerospace industries, as well as working on / leading projects for the architectural and engineering design professions regarding opportunities for High-bandwidth Design Interaction; and on Parametric Modelling at the Early Design stage. The common theme of his research interests (published in over thirty reports, book chapters, and papers) has been the concepts of virtual design and of integrated building information modelling and their potential for encouraging efficiencies and new paradigms in the design, construction and engineering industries.

Mr. Paul Tilley
CSIRO
Division of Manufacturing and Infrastructure Technology
Ph +61 7 3864 4003, fax +61 7 3864 4438, email paul.tilley@csiro.au

Mr. Paul Tilley has been involved in the building and construction industry for over 25 years, starting as a building cadet with the Queensland State Works Department in 1975. After 10 years with the State Works Department, Mr. Tilley decided to enter the world of private industry, working for a number of builders and project management consultants. Over the years, Mr. Tilley gained extensive construction industry experience – in both the public and private sectors – in such diverse areas as: Estimating, Construction Planning and Programming, Contract Administration, Contract Claims Assessment, Construction/Project Management, and Assessment of IT Applications for Construction. In 1995, Mr. Tilley joined the CSIRO's Building, Construction and Engineering Division as a Construction Systems Researcher, to investigate issues relating to construction process efficiency. Areas of research currently being investigated include, Construction Process Re-engineering (CPR), Lean Construction (LC) methods, the efficiency of information and communication flows in construction, the simulation of construction processes and the causes and effects of design and documentation deficiency in construction. Mr. Tilley is also interested in industry benchmarking and in developing indicators for measuring both project and industry performance. He is also a member of the Equitable Project Delivery issue group of the Construction Queensland initiative.

Mr. Todd Remmers
CSIRO
Division of Manufacturing and Infrastructure Technology
Ph +61 7 3864 4491, fax +61 7 3864 4438, email todd.remmers@csiro.au

Mr. Todd Remmers has been involved in the building and construction industry since 1980. In 1981 he started a Carpentry and Joinery apprenticeship, which was completed in 1984. Following the completion of his apprenticeship, he worked mainly in the Home Building Industry in South East Queensland as sub-contract carpenter as well as commercial resort projects around Australia during a two year working holiday in 1988-89. Since completing his Engineering degree, he has worked in Local Government as a Development Engineer. In 2002, Mr. Remmers joined the CSIRO's Building, Construction and Engineering (now Manufacturing and Infrastructure Technology) Division as a Research Assistant, to investigate issues relating to construction process efficiency, facilities/asset management and sustainable built environments. Relevant topics of research relating to this report Mr. Remmers has been involved with include an investigation in to design and documentation quality in the construction industry.