Theme:

Title: **Online Remote Construction Management (ORCM)**

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Abstract: *In an attempt to bring the unique talents of various construction industry project participants together in a more productive and integrated manner, the Online Remote Construction Management (ORCM) project commenced in July 1999 proposing to test, field trial and/or evaluate online information and communication systems on up to five case study projects. This paper outlines two years of ORCM research, surveying and benchmarking activities on one of the five ORCM case study projects and concludes with five 'Critical Success Factors' that would help ensure successful implementation of information and communication technology (ICT) tools and/or Internet-based construction project management (ICPM) communication systems and/or processes on geographically dispersed (remote) civil and building construction projects.*

Keywords: *Construction Industry; Information Technology; Internet; Communication Systems; Remote.*

Introduction- Challenges Facing the Construction Industry

The construction industry is making insufficient use of transferring project data and information electronically. [1] comment that construction organizations are faced with many new challenges, including the need to: change current work practices; become more client orientated; more competitive as well as productive. These challenges are attributable to the many factors that effect the working environment, including: globalisation of the economy; greater performance expectations from the clients; increased competition between local contractors; continued restructuring of work practices, and industrial relations. Currently, information is often 'lost' in the sense that vital information is not retained for easy re-use and must be re-entered, or bulky manuals and drawing folios must be carried, to ensure the employee working out of the office has rapid access to the information needed to perform some of their tasks. Better information sharing between disciplines and the automation tools used can ensure large improvements in the efficiency, productivity and quality of the building industry [2].

Australia, in particular, is a large country with dispersed projects and team members usually headquartered in the major cities and regional centres. Extensive travel is therefore necessary, with inefficiencies in time and delays in decision-making. Nationally, the industry is valued at approximately AUS $30 billion per annum and with preliminary studies indicating that with appropriate utilisation of IT, a 1% improvement in productivity may be conservative, the potential benefit for the construction industry is considerable [3]. It is proposed that more innovative IT (Internet-based) communication tools/systems could be used to help improve the flow of project communications to ensure: that communications occur in a controlled, timely and less costly manner than would traditionally be the case; that information leakage is kept to an absolute minimum; and that all members of the project consortia are in possession of the most up-to-date and accurate project information (Figure 1).

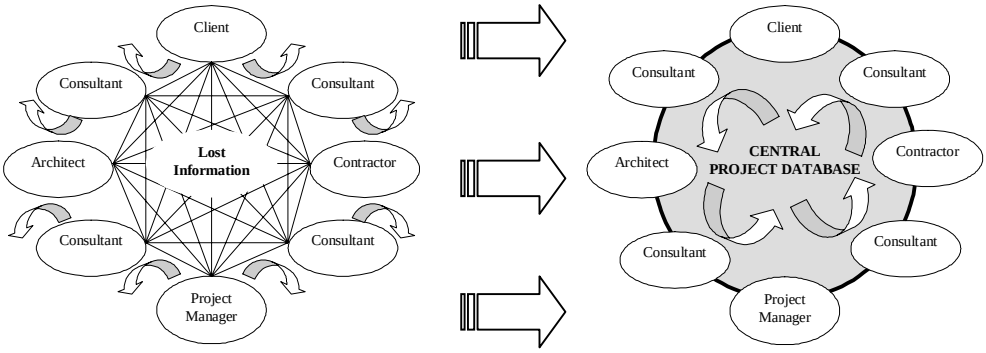

Figure 1: Traditional v Central Project Database

ORCM Research Aim and Objective

The Online Remote Construction Management (ORCM) project - a collaborative research project funded and supported by a number of Australian industry, government, research and university based project partners - commenced in July 1999 aiming, in general, to develop, trial and/or evaluate communications systems on various building and civil construction projects over a two-year period, thereby allowing collaborative design and construction to be undertaken between members of a geographically dispersed project consortium. Additionally, the project aimed to demonstrate leadership in facilitating the use of online technologies for the design, management and construction of building and civil construction projects, by identifying and implementing appropriate communication and information technology solutions that will ultimately: substantially enhance the capacity of design and construction professional and trades personnel to improve the two-way flow of accurate, appropriate and timely information within and between central offices and project sites; lower the effective cost of design and construction; and improve industry efficiency, competitiveness, communication and working relationships of all parties.

ORCM Case Study & Benchmark Project

Research was required into testing, trialling and evaluating the benefits (if any) of implementing an Internet-based construction project management (ICPM) system ('projectCentre' - brief description found in the following section) on a remotely located civil construction project (Case Study Project). This entailed comparing (benchmarking) the 'Case Study Project' against a traditionally delivered (paper-based) 'Benchmark Project' - a civil construction project of similar size, value, location (remoteness) etc, to that of the 'Case Study Project'. With this in mind, the Queensland Department of Main Roads (QDMR) helped identify and provide access to a truly remote 'Case Study Project' (referred to as CSP1) and a 'Benchmark Project' (referred to as BMP1). A brief outline of CSP1 and BMP1 statistics is provided in Table 1:

Table 1: CSP1 Project Statistics

Statistics	ORCM Case Study Project (CSP1)	Benchmark Project (BMP1)
Client	: QMDR	: QMDR
Value at completion	: $ 4.1million	: $ 4.161 million
Project description	: Widening of existing Highway - formation and overlaying with 150mm nominal gravel to achieve fully sealed 9-metre formation (2/3.5m traffic lanes)	: Widening & Overlaying a 9.2 km section of Highway
Delivery system	: Traditional	: Road Construction Contract
Contract time	: 220 calendar days	: 220 days
Completion date	: March 2001	: March 2001
Primary Consultant	: Penna & Company Pty Ltd	: Project Management - DMR
Information Technology	**: projectCentre**	**: Traditional** (paper, facsimile, Radios, PC's)

ORCM Communication Tools Investigated

'projectCentre' was being used as the ICPM medium for project communications and document control throughout the various phases of CSP1. Briefly, 'projectCentre' [4] is a "project web portal" or web-based project management system for construction industry projects. A web browser is required by the project team to gain secure access with the use of a username and password, and/or transmit project documents from any location where Internet services are provided. Project team members send, receive and manage correspondence, requests for information, instructions, variations, drawings and the many other documents involved in the construction process. There is no need for the purchase or installation of software or the download of plug-ins, applets, 'java runtime environments', etc. to use projectCentre.

In contrast, BMP1 project participants made use of the more 'conventional' or 'traditional' forms of communication systems and/or IT tools such as: facsimile, telephone (land line and mobile) and High Frequency 2-way radios, for daily site instructions and other project related communication between the Superintendent, Contractor and other project participants. The Inspector had a Laptop Computer on site for spreadsheet work ('measure ups' for progress payment purposes, etc).E-mail and Internet facilities were not used on this project.

ORCM Research Activities

- **Site Visits:** At the beginning of CSP1, an initial site visit was carried out to meet both the contracting and QDMR staff involved with the project. This meeting was designed to provide details about what the ORCM project involved and answer any questions that they may have had. Due to CSP1 project participants using projectCentre for the majority of their project related documentation and communication, only one further visit to the QDMR district office was required towards the end of the project - to collect any outstanding project information.

  Similarly, regular visits to BMP1 contractor and consultant regional / head offices were undertaken by ORCM researchers to collect the benchmark data.

- **Interviews:** During site visits, formal and informal interviews were undertaken with CSP1 and BMP1 consultants, site staff and other project members and their responses documented. Essentially, interviews were used to gain the confidence of the interviewee, an understanding of the step-by-step logic of a situation as it occurred, and an understanding of the constructs that the interviewee used as a basis for forming opinions and beliefs about a particular event [5].

- **Data:** projectCentre had been used on CSP1 from design through to end of construction phase. Research activities concentrated on collecting and classifying various communication data originating from, or directed to and/or via the Principal, Superintendent and representative, Contractor, consultants, subcontractors and their suppliers. In an attempt to make projectCentre more 'user friendly', projectCentre administrators converted various standard QDMR forms and documents into electronic format for use on the system for the CSP1 project. Additionally, ORCM researchers and members of the projectCentre software development team developed a data 'retrieval/mining program' to assist in extracting the communications data required for ORCM benchmarking activities. Project data was collected regularly and in a systematic manner thereby ensuring no data was overlooked. This allowed the effectiveness and applicability of such ORCM systems to be benchmarked against traditional forms of design and construction management activities.

  Similarly, BMP1 research activities concentrated on collecting and classifying various communication data - originating from, or directed to and/or via the various project participants. Even though BMP1 commenced and finished prior to the ORCM Research Team's involvement, the entire data for the projects was still collected. ORCM researchers and data collectors went through archived BMP1 project files and documents to obtain the necessary information. The bulk of the data was obtained from project site offices and/or contractor/consultant regional/head offices.

ORCM Benchmark Analysis

In this paper we consider CSP1 against BMP1. Both projects were of similar scale, duration and cost (Table 1). BMP1 had no outstanding operational differences and the design / construction documentation for both projects was similar. An "IT in Construction: Benchmark Methodology" report [6] had been prepared by

ORCM Researchers for the purpose of detailing the methodology by which the benchmarking of information technology introduced into the ORCM case study projects were assessed. Benchmarking is described as a process of setting goals by using objective, external standards and learning from others – learning what and why, but more importantly, learning how [7]. Understanding how the companies/projects achieve their results is usually more important and valuable than obtaining a more quantified result.

As the main aim of collecting data on ORCM projects were to record communication flows, it was also considered necessary to concentrate the research on those factors that were generated from a poor information flow processes, inevitably affecting a project's operational and decision making processes, resulting as: rework; Request for Information (RFI); Site Instructions (SI); and variations. The cause, influence and effect that these factors have on a project could then be categorised into a variety of key indicators and classification systems. Yet, in order to determine the validity of these types of indicators, accurate data relating to communication regarding the quality of design and documentation, needed to be obtained. Further, in analysing the information and communication flow on projects, a number of issues were investigated, including but not limited to the: total volume of correspondence issued at different times throughout the life the projects; breakdown of correspondence by correspondence type, sub-category and organisations or discipline/trade; total time involved in the transfer of information; and finally overall and average response times for information requests. Analysis of project data was done in accordance with the ORCM data Collection Methodology Report [8]. *Unfortunately, due to research time constraints and lack of CSP1 project participant's commitment in using projectCentre, the data obtained did not appear to be complete, resulting in ORCM data analysis activities of previously mentioned communication issues to be inconclusive*.

ORCM Information Technology Analysis Framework

Research was required into identifying the benefits (if any) of ICPM systems and/or ICT tools implementation into the construction industry. To achieve this and to ensure a survey could be administered without delay, it was proposed that the Information Technology Analysis Framework, developed for and implemented on Acton Peninsular Project [9] be modified and utilised (with permission from its publication authors) on the various ORCM case study projects. The main aim of utilising this survey was to report on lessons learned regarding the implementation and application of ICPM systems (in this case projectCentre) during the design, construction and project management phases of CSP1 - i.e. to examine and assess project, individual and organisational levels of projectCentre use, as well as identify potential benefits, advantages and/or barriers project participants experienced by its implementation.

Subsequently, CSP1 project participants (including: Superintendent, Superintendent Representative, Contractor and projectCentre administrators) who made use of the various ICT tools (laptop computers, etc) and ICPM communication systems (projectCentre) - to generate, receive, store and/or disseminate all project related documentation, information and communications - completed the ORCM Information Technology Analysis Survey. Responses, ratings, comments and/or suggestions provided by the CSP1 project participants were analysed and assessed in accordance with the framework proposed in [10].

The survey consisted of two sections: In the first, ORCM researchers asked CSP1 project participants to provide a general background to their role in the project as well as provide a record of past and/or existing levels of IT 'exposure' and/or experience on projects. The second section of the survey specifically examined the implementation of projectCentre from seven different but inter-connected perspectives (Figure 2). CSP1 project participants were asked to score each of the seven perspectives by choosing a number between 1 (lowest) and 5 (highest) for each of the weighted criteria's. ORCM Researchers then combined all the scores and manipulated the responses to get an overall percentage (%) or rating for each perspective (Table 2).

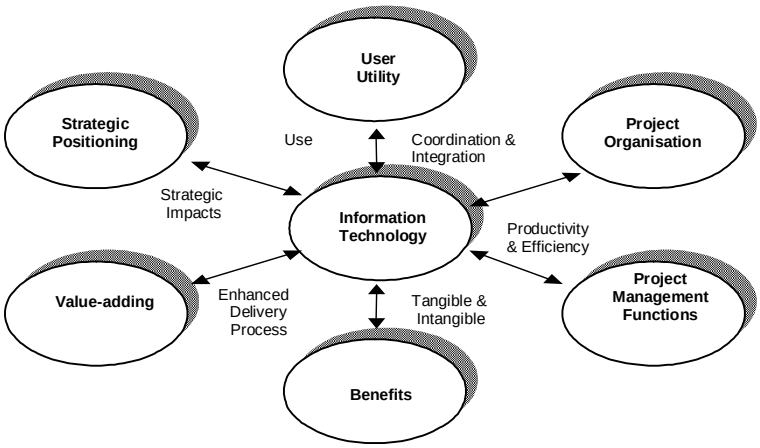

Figure 2: Seven IT Implementation Perspectives [9]

Table 2: Key to Figure 2

Perspective	Description
1. Information Technology	**:** Centre of the framework - focuses on IT tools used and addresses their technical aspects.
2. User Utility	**:** Concerned with user satisfaction and perceived value of IT use. User satisfaction is expected to play an important role in the overall evaluation of the IT tool.
3. Project Organisation	**:** Deals with the role IT plays in facilitating the integration of project participants.
4. Project Management Functions	**:** Examines the impact of IT on project management functional goals, mainly in the areas of information needs, quality and timeliness within the context of design, construction and project management functions.
5. Benefits	**:** Investigates the link between IT implementation and any project-related short-term benefits - both tangible and intangible. Tangible benefits such as time and cost savings are expected due to the reduction of paper-based workload, faster response times and less rework. Intangible benefits may include process flexibility in generating, handling and manipulating data, ease of workload, and ability to detect errors or inconsistencies.
6. Value-adding	**:** Capturing the relationship between IT implementation and the overall project delivery process and is a much broader concept than that of the benefits perspective. It examines the perceived value-added aspect of the process in terms of generating business value to the client (delivering a project through a more robust delivery process) as well as to all project stakeholders (cultural change and extended partnerships).
7. Strategic Positioning	**:** In addition to evaluating IT use in a particular project, there is also a need to measure and evaluate IT contribution to the strategic capability of the organisation. It is concerned with how lessons learned in this project are disseminated and hence contributed to the strategic positioning of the organisation.

Finally, ratings (%) for the above seven perspectives were 'ranked' (Table 3), providing an indication of project participants' overall level of satisfaction in using projectCentre on CSP1.

Table 3: CSP1 – Ranking of 7 Perspectives

Ranking	Perspective	Rating (%)	Level of User Satisfaction and/or Influence on the Project
1st	Information Technology	68%	Highest
2nd	Project Management	62%	Above Average
3rd	User Utility	58%	Average
4th	Strategic Positioning	56%	Average
5th	Value Adding	55%	Low - Average
6th	Project Organisation	53%	Low
7th	Benefits	52%	Lowest

Results show that the CSP1 project participants rated:

- projectCentre's **'Information Technology'** perspectives the highest (68%): pertaining to projectCentre's reliability, secureness against unauthorised use, user-friendliness, appropriateness for the application/function, and suitability for site conditions; and the
- link between projectCentre's implementation and any project-related short-term **'benefits'** (both tangible and intangible) the lowest (52%): indicating project participants were not entirely convinced with projectCentre's ability to save time (e.g. processing, responding, etc), save cost (e.g., rework, travelling, overheads), improve document quality, decrease number of design errors and number of RFIs.

ORCM 2nd Questionnaire

In addition to the ORCM IT Analysis Survey, research and analysis was required of a more qualitative or 'descriptive' nature with regard to the level of 'impact' the various ORCM Case Study project participants perceived the implementation of an IT tool and/or communication system's had on projects. CSP1 project participants and users of projectCentre were asked to respond to fifteen questions (Table 4) to help ORCM researchers determine/evaluate (from the end users perspective) any strengths/weakness; advantage/disadvantage; success/failures; areas for improvement; process and/or implementation gaps; future recommendations; etc.:

Table 4: ORCM 2nd Questionnaire

#	Question
Q1	: What has gone well with the use of projectCentre in this project?
Q2	: What has not gone so well?
Q3	: What problems have you had with implementing and using projectCentre?
Q4	: How have the above problems been addressed?
Q5	: Has the use of projectCentre improved communications in the contract?
Q6	: How have you and/or your organisation overcome administrative and legal issues associated with using electronic as opposed to traditional methods of communication?
Q7	: What types of communication are most suited to a projectCentre process?
Q8	: What types of communication would you recommend that one should not use a projectCentre process for?
Q9	: Has projectCentre improved efficiency on the project?
Q10	: Has projectCentre assisted relationships on the project?
Q11	: Would you recommend the use of projectCentre on future construction projects?
Q12	: Would projectCentre be useful for pre-construction or maintenance activities?
Q13	: If so, how?
Q14	: What should one do to more effectively use projectCentre?
Q15	: Include any additional comments, recommendations, etc. that you may have regarding the implementation of projectCentre

Unfortunately not all of the CSP1 project participants who completed the ORCM IT Analysis Survey were available to complete the 2nd ORCM Questionnaire due to other commitments and/or time constraints. Yet, ORCM researchers were still able to identify certain 'qualitative' problems, issues, limitation or process gaps experienced during the implementation and use of projectCentre on the project. Further data may well yield significantly different results for this project.

ORCM Critical Success Factors

In summary, the ORCM Research Team, through various research activities (including: implementing two ORCM questionnaires, carrying out formal and informal interviews and undertaking extensive benchmark analysis activities) identified the following five success factors that would be critical in helping ensure successful implementation of information and communication technology (ICT) tools and/or Internet-based construction project management (ICPM) communication systems on geographically dispersed (remote) civil and building construction projects:

1. **One System:** One Project – One Team – One System. Project participants want to learn to use only one ICT tool or ICPM system for ease of understanding its capabilities, etc:
   - System Compatibility: *The capabilities and functionality have to be compatible with most other ICT products and ICPM systems used in the industry – potentially saving overall implementation time, cost, labour, errors, etc. Application of an ICPM system must not be a "black box" of information processing.*
   - Ease of Data Entry: *Commonality of an ICPM system's access features and ease of data entry is most important. Free access to downloadable and compatible readers and 'plug-ins' for common access to data must be provided by ICT tool and ICPM communication system developers. Either there is one industry/client wide system or there is a common user interface.*
   - Fully resourced Implementation: *Trialling an ICPM system (that has not had much exposure to industry participants) should be treated as a 'special case' with proper backing, support and experience from developers, implementers and researchers – i.e.: to ensure that all aspects are covered during the early stages of its implementation (e.g.: reliability, capability, etc. of essential project communications).*
2. **End User – Prime Focus:** The end user is a key factor in gaining advantage from an ICPM system. Taking only the type or potential advantages, capabilities, etc of a newly developed ICT tool or ICPM communication system into consideration is not enough during implementation. End user needs, expectations, requirements, recommendations, comments, etc must be a prime focus:
   - User v Quality and Accuracy: *The quality and accuracy of any project related communication or information (electronic or paper based) is directly dependant on the user or creator of that piece of information or correspondence (with or without an ICT tool) - technology alone is not enough to guarantee improved quality and accuracy of project related communications.*
   - Trust: *Implementing a new ICT product or ICPM communication system must create a feeling of trust (reliability, relevance, need, etc.) for potential users.*
   - Designed for the industry by the industry: *Whilst developing a new ICT product or ICPM system, the end users must be involved from the beginning to ensure a greater chance of successful ICT uptake.*
3. **Training:** Training in the use of a new ICPM system is essential. This includes continuous access to a telephonic or online 'Help Desk', regular onsite demonstrations and 'refresher' training sessions to ensure continuous learning and understanding of what the system is capable of, as well as recognising and accepting its limitations.
4. **Commitment:** All project participants and stakeholders need to be fully committed to using the new ICT tool or ICPM communication system, with "buy in" and collaboration at the highest level within participating companies, thereby reassuring and guaranteeing potential users of a 'corporate commitment'.
   - IT Driver: *Every project should have a 'driver' of ICT uptake (Superintendent or equivalent), encouraging, supporting and monitoring its application and use throughout all phases of a project.*
5. **Legal Issues:** ORCM 'Critical Success Factors' are susceptible to the current legal status regarding electronic transmissions, the use of electronic signatures, etc. Commitment by both government and industry sectors is required to help develop more innovative strategies to build a stronger and more competitive construction industry. ORCM Committee Members and their organisations have sought legal advice regarding the use of electronic communications on both public and private sector projects. These investigations are aimed at strengthening organisational and individual legal status when utilising electronic transactions or communications on building and civil projects, providing better management of risks such as [11]:
   - Authenticity: s*ource of the communication - does it come from the apparent author?*
   - Integrity: w*hether or not the communication received is the same as that sent - has it been altered either in transmission or in storage?*
   - Confidentiality: c*ontrolling the disclosure of and access to the information contained in the communication.*
   - Evidence: *e-communications meeting current evidentiary requirements in a court of law (e.g.: a handwritten signature).*
   - Jurisdiction: t*he 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.

Conclusion

This paper attempts to demonstrate the need to facilitate the use of Internet-based construction project management (ICPM) information and communication technologies (ICT) for the design, management and construction of remote located building and civil construction projects. ORCM '*Critical Success Factors*' help reinforce the need for further research and development (R&D) of identifying improved implementation procedures and ICT application opportunities within the construction industry. Increased 'encouragement' in using such innovative technologies will help reduce current industry levels of: resistance to change; organisational and cultural 'barriers'; and traditional work 'habits' as experienced on CSP1. Future research activities, similar to the Online Remote Construction Project (ORCM), will enhance current levels of ICT and ICPM system knowledge, awareness and skills of all industry stakeholders, and integrate the world of construction in a way that we have never experienced before. *"Without doubt the ability to bring people and technologies together in two-way communication will have major social impact and integrate the world in a way that we have never experienced before"* [12].

Acknowledgements

The ORCM project was a major research project undertaken by the Queensland University of Technology (QUT) Commonwealth Scientific Industrial Research Organisation (CSIRO) Construction Research Alliance, based at the Queensland University of Technology, Brisbane, Queensland, Australia. This research project was jointly funded (July 1999 to December 2001) by the Queensland Government Information Industries Bureau (IIB) Department of Communication and Information, Local Government, Planning and Sport; the Queensland Department of Main Roads (QDMR); the Queensland Department of Public Works (DPW); and the Queensland University of Technology.

References

1. **Love, E.D. and Mac Sporran, C., (1996):** *The Use of Information Technology by Australian Construction Contractors,* The Chartered Building Professional, June.
2. **Howell, I., (1996):** *The Need for Interoperability In The Construction Industry*. In Proceedings of the InCIT 96 International Construction Information Technology Conference, Sydney, Australia, April.
3. **Fujitsu Centre, (1998):** *Information Technology in the Building and Construction Industry: Current Status and Future Directions,* A Report for the National Building and Construction Committee Department of Industry, Science and Resources, Australian Graduate School of Management and Building Research Centre, Faculty of the Built Environment, University of New South Wales, August.
4. **ProjectCentre, (2001):** Web Site - http://www.projectcentre.net/
5. **Weippert, A. (2000):** *Project Communication: Traditional v Electronic,* Master of Project Management, QUT Brisbane, Australia.
6. **Weippert, A., Kajewski, S. and Tilley, P., (2000):** *Online Remote Construction Management (ORCM) IT in Construction: Benchmark Methodology Report,* QUT Brisbane, Australia.
7. **Boxwell, R.J., (1994):** *Benchmarking for Competitive Advantage,* McGraw-Hill Inc, United States of America.
8. **Tilley, P.A., (2000):** *Communication and Information Flow in Construction: Methodology Report,* for On-line Remote Construction Management (ORCM) Project Steering Committee, QUT/CSIRO, Brisbane, Australia.
9. **Tucker, S.N., Mohamed, S. and Ambrose, M.D., (2000):** *Information Technology Analysis Framework for Acton Peninsular Project,* Report for Department of Industry, Science and Resources, CSIRO and QUT.
10. **Kajewski, S., Weippert, A. and Tilley, P., (2000):** *Online Remote Construction Management (ORCM) Information Technology Analysis Framework,* QUT/CSIRO, Brisbane, Australia.
11. ***Electronic Transactions Act* (1999):** Act No. 162 of 1999, prepared on 22 August 2001, Prepared by the Office of Legislative Drafting, Attorney General's Department, Canberra. - http://scaletext.law.gov.au/
12. **Brandon, P., (2000):** *Construction IT: Forward To What?* INCITE 2000 Conference, Implementing IT To Obtain a Competitive Advantage in the 21st Century, The Hong Kong Polytechnic University, Hong Kong, January.