

## **Electronic Documentation Management in Construction Projects – A Qualitative Study**

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### **Abstract**

Information and communication technology (ICT) has opened new avenues for businesses to communicate and exchange documents with advantages such as faster communication and reduced costs compared to traditional communication methods, not to mention the environmental benefits associated with paperless offices. Organizations within the construction industry have recently been integrating electronic documentation management (EDM) systems into construction projects, in an effort to increase efficiency. Semi-structured interviews were undertaken with industry practitioners in South Australia to understand the current practice of EDM systems and their perceptions of the benefits of adopting EDM systems in construction projects. The results showed that there has been a rapid transition from hard copy format design and documentation to electronic formats with the advancement of information and communication technologies. The adoption of EDM systems is perceived to correlate with the improved efficiency of communication within the project team and in turn better project outcomes. Implications are discussed.

### **Keywords**

Electronic documentation management, efficiency, construction projects, South Australia

## **1. INTRODUCTION**

Information and Communication Technologies (ICT) has changed nearly all aspects of the manner in which businesses operate, including those within the construction industry. The evolution of ICT has led to common informal ICT use in the construction industry (e.g. E-mail communication) but, as of yet, limited use of it for formal communication and business management (Rowlinson & Croker 2006, p.155). ICT has opened new avenues for businesses to communicate and exchange documents with several advantages such as paperless offices, faster communication and reduced costs compared to traditional methods. Construction organisations are now shifting from their traditional, tried and tested methods to embrace new technology. Such changes can prompt these businesses to improve traditional business processes, innovate their products and services, and develop strategies that are flexible to incorporate new technologies as and when they emerge (Anumba & Ruikarm 2002).

The construction industry is often criticised for its poor performance (Wong & Fung 1999) relating to communication and collaboration. One identified reason for this is the fragmented nature of the industry due to the many stakeholders and phases involved in a construction project. This fragmentation has led to well documented problems with communication and information processing and has contributed to the proliferation of adversarial relationships between the parties to a project. This fragmentation is also often seen as one of the major contributors to low productivity in construction (Nitithamyong & Skibniewski 2004).

Electronic formats of project documentation are now widespread throughout the construction industry and will become more popular as ICT is further advanced in the future. Rivard et al. (2004) suggested the construction industry has experienced a paradigm shift from traditional paper-based to digitally based information exchange in recent years. A number of web-based “construction collaboration technologies” (CCTs) have emerged and been implemented within projects to manage project information and store this information in a centralised database available to all project stakeholders. With the ever increasing progress of Internet-based ICT, it is critical for organisations operating within the construction industry to take advantage of modern systems in order to collaborate more effectively and increase the efficiency of their systems and processes.

The aim of the research is to examine construction professional’s experiences and perspectives of electronic documentation and associated document management systems and the impact they have on project success and communication streamlining. Objectives are: (1) to investigate how electronic project documentation and document management systems have evolved in the local construction industry; (2) to investigate what impact currently used electronic documentation and document management systems have within projects.

## **2. LITERATURE REVIEW**

A construction project is a complex activity involving a large number of parties, e.g. the client, architect, structural engineer, fabricator and the contractor. It is a team effort, involving several, inter-organisational activities and dialogue (Anumba & Ruikarm 2002). Document management and control is critical to the flow of information amongst project team members within construction projects and forms the basis for the translation of design into the reality of a project.

Project documentation can be described as a collection of documents that translate the ideas of the design team into the reality of the project. Project documentation is normally made up of a number of drawings and specifications, broken up into the various components such as Architectural, Services and Civil / Structural. It is the responsibility of the design team to coordinate and liaise together in order to develop well designed and clear documentation, which can be issued to a Contractor and interpreted accurately. Documentation needs to be translated on site easily, without a constant need to go back to the design consultants with “Requests for Information” (RFI’s) and problems relating to the coordination of the plans and specifications. Documentation is transferred between project team members throughout all stages of a project’s timeline, from early design, tender and then construction and practical completion. It is critical for the correct documents to be transferred to the correct project stakeholders quickly, for there to be uninterrupted flow of communication and to minimise delays and errors made on site.

ICT has had a significant impact upon all industries over the past 10-20 years, primarily in the way in which people communicate and collaborate with one another. Rowlinson & Croker (2006) suggest the evolution of ICT has led to a widespread use of informal communication within the construction industry, but limited use of such technology for formal communication and business management. This research also identified that the construction industry generally lags behind other industries in the uptake of these technologies and when they are implemented they are generally of ‘informal’ nature, meaning that all firms will set up their own systems and procedures and there is minimal continuity throughout the

industry (see also Rivard et al. 2004). Love & Irani (2004) identified a number of barriers for entry for small to medium sized construction organisations to implement ICT systems such as initial outlay costs, resources, and training for employees.

Electronic Documentation is a term used to describe documentation produced by design consultants, such as architects and engineers, in an electronic format. Drawings are now developed using sophisticated design software, which comes under the label of Computer Aided Design (CAD). Completing design and documentation using this method offers designers a number of advantages over past hand drawn formats, including increased speed, ease of coordination with other electronic drawings and increased speed to distribute to other project team parties. Traditional hand drawn design and documentation formats have become close to redundant, other than early sketch design, which architects may still utilise this method. CAD has become standardised across the construction industry approximately ten years ago, which has had a significant impact on design methods and to some degree changed the mentality behind project design and documentation (Rivard et al. 2004).

Electronic Document Management (EDM) is a term to describe the concept, in which all project documentation is managed and stored in electronic formats, primarily as a mechanism to increase productivity within projects. Björk (2003) stated that EDM systems focus on facilitating the management of document pertinent to particular enterprises, project and work groups in computer networks. Organisations within the construction industry have recently been integrating EDM systems internally, in an effort to increase efficiency and functionality within projects. This has only been made possible in recent years, due to ICT becoming so widespread within organisations and reaching a point of functionality, which has enabled users to rely solely on EDM systems. Bäckblom, Ruohtula & Björk (2004) suggested that the primary barrier in the uptake of EDM systems within the construction industry was a psychological resistance from key players in design and construction teams, which can be interpreted as a “fear of change”. Investigating a number of e-commerce models appropriate for construction organisations, Anumba & Ruikarm (2002) concluded that electronic commerce and EDM systems are changing the way in which projects are managed and implemented, due to the benefits these systems offer to the construction industry in terms of greater collaboration, efficient dissemination of project information, and cost reduction.

Construction Collaboration Technologies (CCTs) are a form of web-based EDM system, in which all project documentation is centralised in one location and can be updated and distributed to various project team members, to minimise errors and inefficiencies associated with informal document distribution systems typically used in the construction industry. Such systems have been named variously, including Document management system Project Extranet, Project web, Project Bank, Project Specific Web site, Document Pool, Project information management system, Virtual Project (Björk 2003). Duffy, Graham & Thomas (2007) argued that along with the rapid increase and widespread usage of ICT within the construction industry, a significant problem has appeared associated with informal communication and distribution of documentation between project participants. Similarly, CCTs have the capability to manage all documentation within a project, which can be utilised as opposed to communication via informal E-mail for example. By managing and storing all project documentation and communication within a centralised location, this offers a number of benefits and efficiencies to all project team members. According to Nitithamyong & Skibniewski (2006), there are four general categories of construction project information that are carried out within CCT systems, i.e. project information, design information, management information and financial information.

### **3. RESEARCH METHODOLOGY**

Semi-structured interview is adopted in this study to fulfill the research objectives. The construction industry is made up of a diverse range of professionals with different expertise. Documentation is produced by design consultants in order to convey the ideas and designs intended for a contractor to

translate into a real life building or other material thing. All parties involved on a project are a vital part of the communication chain and must deal with varying aspects of documentation and its management. Therefore, it is critical to approach a range of consultant professionals, in order to ascertain varying experiences and insight into the research topic and its associated themes. Primarily design consultants have been sought for these interviews, due to their role to produce project documentation and the insight they could provide into past and current documentation practices, as well as emerging trends and the impact new technologies may play on projects into the future.

A further series of structured interviews has been carried out with local head contractor Project Managers, to further examine documentation practices from a Contractor's perspective and to investigate the way in which electronic documentation and current management practices have impacted upon their operations and systems. This helps to clearly identify the direct impact electronic documentation and its management has upon local construction projects and the way in which they are delivered. Project Managers have been selected for this interview process, due to the central position they hold within project communication lines and their responsibility to ensure document management systems and procedures are well established and managed within their projects, to ensure documentation can be communicated effectively between project stakeholders effectively.

Snowball sampling is adopted in order to identify most appropriate industry professionals to participate in this research. 6 design consultants and 4 contractors were interviewed. A total of 10 interviews were undertaken. Interviewees referred to a range of projects during interviews such as commercial developments and housing developments. All interviewees have at least 5 years professional experience. Each interview took 1-1.5 hrs. Interview questions are:

1. How has project documentation changed in last ten years?
2. How critical is the proper management of project documentation within projects?
3. What are the benefits associated with primarily using electronic documentation on projects?
4. What are the disadvantages associated with primarily using electronic documentation on projects?
5. How has communication technology impacted the way in which projects are operated?

Data collected during interviews were coded and subsequently analyzed.

## **4. INTERVIEW FINDINGS**

### **4.1 Transition to electronic documentation management**

The responses from the design professionals were consistent; acknowledging that the transition they have seen from hard copy design documentation to CAD based systems took place between 1995 and 2000. It was acknowledged by all design consultant interviewees that for the last 10 years, the majority of all design and documentation has been produced with a range of CAD software systems. The responses identified the major benefits of working with electronic based systems, including increased speed and ability to amend documents quickly in comparison to hard copy formats.

All design consultant interviewees acknowledged that the majority of early stage concept and sketch design is still generally hand drawn, mainly for the reason that using this technique gives the user more creative ability to produce concept drawings for presentation to other design team consultants and clients. This indicates that designers have not yet reached a point where all design work is produced on computer based systems. One design consultant interviewee suggested that the document management concept has not changed too drastically over the past 10 years, but the medium through which these systems are used to deliver the documents is the true change. The biggest difference with current systems is the rapid speed and immediate fashion in which information can be broadcast, which can have a significant impact particularly in the construction industry, where time can be such an important to project success.

Three out of four contractor interviewees reported that their companies currently have in place consolidated electronic document management systems, operating across all projects and personnel. One of these acknowledged that this system has only been implemented within the past two years, before which all documents a primarily hard copy document system was being used.

#### **4.2 Benefits of electronic documentation management**

All interviewees agreed that it is absolutely critical to project success by ensuring project documentation is well managed throughout a project. Design consultant interviewees showed that issuing and properly tracking updated documentation is vital in order to establish and maintain effective communication flow between the design team and construction team, particularly within large scale projects where a significant number of consultants are collaborating. Not having this successful communication flow can potentially cause significant problems to projects, such as project delays, increased variations & project costs, and lack of co-ordinated documentation.

According to design consultant interviewees, it is critical to establish proper protocols and for coordinating and issuing documents both within the design team and with the distribution to contractor for construction. Abiding by strict rules and protocols enables all project parties to establish their own documentation management systems, with their organisations. The electronic documentation has changed the way in which project documents are now managed and has forced organisations to embrace new systems and protocols. For example, currently the majority of drawings are produced with CAD systems and distributed between design consultants for coordination, which makes it is easy for users to simply add extra “layers” to the CAD file. This can cause drawing to become congested with old and new information and easily cause confusion for other users. To prevent this type of confusion occurring, design consultants must follow strict protocols and systems when coordinating electronic drawings.

Increasing the speed of document distribution was the most commonly identified benefit of using electronic format documentation and communication systems. For the design consultants, being able to broadcast revised documentation almost instantly to recipients generally via E-mail transfer is a huge advantage compared to past hard copy distribution systems. It could take up to a number of days to distribute documents using traditional hard copy distribution systems, by the time the documents are produced and received by the end user. Making quick amendments to electronic format drawings and specifications is an important advantage, where items of a drawing or specification can be quickly changed or deleted and using the “save as” function of the software package in order to supersede the previous document revision. Simplifying drawing coordination was another common advantage identified within the responses to this interview question. With a number of design consultants from different disciplines all producing their own drawings, having the ability to “overlay” a number of these over the top of each other to produce a consolidated drawing can be extremely useful to find potential clashes and to resolve other coordination issues. With a number of CAD software packages now supporting 3-dimensional (3D) drawing, coordination becomes even simpler, as design consultants have the ability to overlay their drawings with one another in a 3D environment and further investigate coordination issues.

According to contractor interviewees, the EDM systems not only incorporate all project documentation and correspondence, but also administrative documents for the project manager’s use such as progress claims, RFI’s, variations and other documents to track activity relating to the project. It is also understood that the organisations’ accounting systems are partially integrated within the EDM system in order to streamline the accounting process and provide access to documents between the systems. The information within the EDM systems is stored centrally on a server, which enables all users of the network to access documents stored in this location as well as update / add new documents & delete documents. Storing all information centrally on a server is critical for the core functionality of EDM systems, to enable all users

access to different levels of information and also offering benefits such as security and backup of information.

### **4.3 Challenges of electronic documentation management**

With the current practice of using CAD systems to produce drawings, design consultant interviewees share the view that less thought is now being put into the design process, because there now exists an expectation in the industry that drawings can be produced very quickly by designers. This can be detrimental to overall design of projects and can have a significant impact on such aspects as document coordination and development. One interviewee highlighted that this can have an impact on dealing with constructability issues, as less time is now allowed to deal with type of issues during the design and coordination of documents, which can cause significant problems and delays during the construction phase of a project.

Another challenge highlighted by design consultant interviewees is that because it is so simple to amend drawings and documents and supersede the previous issue, this generally leads to a greater number of document issues during both tender and the construction phases of projects. This puts more of a demand on the document management and communication systems in place, to ensure that all project parties are provided with the latest relevant information. This, in turn leads to more work for all parties, in order to keep up with the latest issue documents and be able to coordinate effectively. One interviewee pointed out that "...on larger scale projects, with a number of different design consultants it can be quite daunting attending to all of the communication you received, a significant part of which may not be relevant to your discipline or role as part of the design team". In this case, there can be a tendency to broadcast the latest information to more people than actually require it, which can impact everyone's efficiency.

One common theme identified by contractor interviewees was the range of capabilities of subcontractors to receive electronic documentation. It was highlighted by all project managers that there exists a spectrum of subcontractors in the market, which vary from highly sophisticated large organisations to single person operations. The larger subcontracting organisations (generally which are services and structural trades) are known to have a high level of technical capabilities, which enables them to receive project documentation in electronic format and work with CAD drawings to produce shop drawing, for example. It was conveyed by the project managers that these types of subcontractors prefer receiving documents in this format, due the speed and efficiency associated with these. On the other end of the spectrum, smaller subcontractors generally have lower technical capabilities, i.e. No E-mail address, still communicating primarily through facsimile communication. To effectively deal and communicate with these subcontractors, the construction organisations must use hard copy format communication and documentation, which means printing plans and specifications, as well as communicating via facsimile and regular mail. Utilising these outdated systems, when an organisation has an effective EDM system in place, is inefficient but still required until the uptake of ICT within smaller subcontractors increases. The project managers acknowledged that this uptake is gradually increasing, but will take a number of years before all documents and communication is transferred electronically. Within the middle of this spectrum, the majority of subcontracting organisations now prefer to receive all documentation in both electronic and hard copy formats and prefer correspondence to be via E-mail. As a result, document distribution is not consistent across all subcontractors and both electronic and hard copy format systems need to be utilized.

One contractor interviewee indicated that the organisation's management is hesitant to implement a complete EDM system and phase out hard copy documentation, due to management being made up of employees of an older generation, who are generally not completely comfortable with utilising EDM systems and prefer to also keep hard copy documents as well. This raises the issue, regarding perceptions of people from different generations and the technology they are comfortable with. As more ICT is

implemented within construction companies, due to the obvious benefits associated with these systems, people from older generations will adapt and become more comfortable with ICT based systems, although this process will take some time.

#### **4.4 Future developments of documentation and communication technologies**

From a design and documentation perspective, design consultants identified 3D based CAD software systems (also known as Building Information Modelling or “BIM”), one example of which is Autodesk’s “Revit” are the next step forward for design technology. For designers, having the ability to design and collaborate within a 3D environment, as opposed to existing 2D software packages, changes the whole mentality associated with designing and documenting projects. This type of software technology enables designers to essentially create 3D models of buildings & structures, from allows for a number of advantages, including:

- Increased collaborative approach between design consultants – coordination to find potential clashes, etc.
- Snapshots can be taken to produce standard drawings – plans, elevations & sections.
- Models can be textured for presentation of renders and “fly-throughs” for a client.

Three of the design consultants conveyed that their organisations were in a transitional phase into implementing Revit to replace all currently used CAD systems. Initially, this may present a number of challenges for the organisation and the users to become familiar and efficient in using the new software, however they believe it is worth the investment now to gain a competitive advantage into the future, as this type of software infiltrates the industry.

In regards to future trends for documentation and communication management systems, design consultant interviewees recognised that all systems will gradually evolve into web-based centralised systems, improved versions of CCT systems available on the market now. Having one CCT system that all users are familiar with, with a lower cost on the project would rapidly increase the uptake of these systems and they could be used across all projects, not limited to large scale projects.

One design consultant proposed by combining 3D environment based design software and a web-based CCT system, this would enable a “live” model to be worked on simultaneously by any number of designers and provide the a highly sophisticated collaboration tool to produce a building model efficiently and with minimal errors.

Contractors interviewees proposed some potential improvements to the EDM systems currently being used:

- Improving efficiency of template systems. For example RFI, instruction, variation templates all should automatically be filled out, to enable the user to quickly enter information into the relevant fields and without needing to enter information which could be automated by the EDM.
- Integration of the EDM and the financial system, in order to connect all project documentation with financial reporting such as progress claims, subcontractor invoicing. This would enable one consolidated system, with access to all documentation by users.

## **5. CONCLUSION**

This research adopted a qualitative approach to investigate the electronic documentation management within the construction industry. Interview with selected industry professionals in South Australia found that rapid uptake of ICT within construction organisations has led to documentation and document management systems transitioning from paper based to electronic format. The majority of organisations

within the local construction industry have implemented EDM systems as their primary document management systems, due to benefits primarily through efficiency and increased control. These systems are generally operating alongside a hard copy document system as a backup. CCT systems are becoming increasingly popular within local construction projects; due to the range of benefits they offer all project team members and clients. The primary barriers for increased implementation of these systems are cost and familiarity for users. Project documentation is now almost completely produced in electronic formats through the use of CAD software systems. These type of systems offer designers a range of benefits including increased speed and improved collaboration with other disciplines. 2D CAD software systems have been the industry standard for approximately the past 10 years and continue to be the most prevalent design and documentation tool. 3D CAD software systems (BIM) are gaining some momentum and are viewed as the next significant progression for designers, in terms of increased collaboration and efficiencies. Construction organisations are prepared to embrace future developments of ICT, to refine their systems and increase their competitive edge in the market.

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