THE ORCM EXPERIENCE – A MAIN ROADS ODYSSEY

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Abstract

This paper describes trials in the Queensland Department of Main Roads of Online Remote Construction Management (ORCM), the aim of which is to use electronic communication technologies to enhance online real time communication between the parties to a construction project, and thus improve the roadworks delivery process.

ORCM uses electronic communication processes (such as the Internet) to maximise the use of time of personnel engaged in construction projects and reduce the large amounts of paperwork generated in many construction projects. It has particular advantages where the parties in a project are geographically dispersed.

Trials of this methodology by the Department are taking place in both rural and urban areas, as part of a wider research project being undertaken by the Queensland University of Technology and the Commonwealth Scientific and Industrial Research Organisation, in conjunction with a number of government Departments and some private industry partners. This research is evaluating the issues and benefits associated with the implementation of this methodology.

A typical trial site is described. This site used an Internet based ORCM process to manage communications between principal’s representative, superintendent and contractor.

The trials to date have shown that the ORCM approach has definite potential to be successful in improving project communication and the efficiency of project supervision. It provides a single database of contract related information, can save time and can be used to disseminate project information to stakeholders through the Internet.

In order for this approach to achieve its full potential, the project site requires to be a fully operational component of the electronic communication process, and those using the software require to be fully trained in it. Management styles, relationships between the parties involved and readiness to embrace cultural change all play a role in the success of this process.

The wider use of ORCM also requires further consideration of risk management, and in particular the management of legal and systems related risks, including data security, integrity and related matters, and the need to keep records in a suitable form for archiving. The continuing development of technology and of appropriate legal frameworks with respect to electronic transactions are expected to assist the management of such risks.

The next proposed stages of the research are trials of ORCM in pre-construction and maintenance, enhancement into a total intelligent project delivery process through adding to the process other technologies such as video conferencing and wireless transmission, and incorporating into the process electronically aided design and project management technologies.
Introduction

As it strives to be more competitive on a world scale, yet sensitive to the needs of the community which it serves, the construction industry is undergoing a number of changes. As part of these changes, the construction process is being re-engineered, there is a strong move to relationship contracting, and extensive use is being made of electronic advances such as electronic commerce.

One of these changes is the increasing use of advances in electronic communication to maximise the use of time of personnel engaged in construction projects and reduce the large amounts of paperwork generated in many construction projects. For example, there are considerable potential savings in reducing the time spent travelling to meetings to resolve issues. Similarly, reduction in the amount of paperwork generated as part of the quality assurance process, and improved time in making design decisions are expected to reduce project costs, enable improved risk management, and assist improved relationships between the parties to a contract.

Ability to achieve such results is enhanced by those advances in electronic communication which allow collaboration between the parties to a contract across a wide area network. Such collaboration is likely to assist rapid resolution of outstanding project issues and reduce unnecessary travel time. Use of advanced electronic communication will also enable better communication between design offices and project sites, and thus help both site and design personnel to understand each other’s position better. It will also assist in managing project knowledge through maintaining records in a central location.

This process of using electronic communication between the parties to a construction project is known as Online Remote Construction Management (ORCM). In its most common form, ORCM uses the advantages offered by the Internet to facilitate communication between the parties to a construction contract, including designers, over wide geographical areas. Members of the project consortium may have different software and hardware, and different requirements and expectations, but are able to communicate, using ORCM, through a shared database approach.

Main Roads is currently testing ORCM processes on a number of sites in Queensland, with the eventual aim of developing this process for use in truly remote regions. While the initial projects in this trial are construction projects, the process is also being considered for pre-construction and has potential to be extended to maintenance activities.

A two year research project, involving a partnership between academia, government and industry has been undertaken to implement, trial and evaluate this methodology. The research is being led by Queensland University of Technology (QUT) and Commonwealth Scientific and Industrial Research Organisation (CSIRO). Main Roads is a sponsor of and contributor to this research project.

This paper discusses potential benefits and issues in the application and use of ORCM.
The Need for Advanced Communication

The benefits of information technology in the construction industry are yet to be fully realised. For example, a 1999 survey of the Canadian construction industry reported by Kajewski and Weippert (2000) found that most firms have adopted e-mail and the Internet, but that most processes within the firms are still not computerised. This picture does not appear to be uncommon.

ORCM, which is now being used by some leading construction organisations, but appears to be in its infancy as far as general usage is concerned, is one technology which is expected to foster the increased use of electronic communication in the construction industry.

As its name implies, Online Remote Construction Management is the use of advanced electronic and related technologies to facilitate project management through enhancing online real time communication between the parties to a construction project. It aims to enhance the capacity of design and construction personnel to improve the two-way flow of information between central offices and remote project sites; improve industry efficiency and competitiveness; and lower the effective cost of design and construction.

ORCM provides an enabling technology to facilitate construction process re-engineering (CPR), or the application of business process re-engineering (BPR) to construction projects. One definition of CPR is “a customer-focussed approach to progressively develop delivery process focusing on optimising project predictability and enhancing the value of the final product” (Mohamed, 1997). The application of CPR is expected to be able to deliver improvements in time and cost of works projects.

In a typical ORCM application, the parties to a contract may well be at geographically dispersed locations and are likely to be using different project management tools and different software applications.

A good example of the above is a road widening and rehabilitation project in Central Queensland, Australia, on the Dawson Highway between Banana and Rolleston (south of the town of Emerald). In this project, which is known as the “West of Little Roundstone Creek” project, the principal’s representative and superintendent were located in Emerald; the designer in Rockhampton; the contractor’s head office in Townsville; and the project over two hours’ drive south of Emerald (see Figure 1).

In such a construction project, there are a range of regular formal communications between the parties. These communications may include:

- requests for information;
- site instructions;
- correspondence;
- quality records;
- meeting organisation;
- meeting minutes;
- progress records;
- photographs;
- drawings;
- progress claims and payments.
Each party sees such communication from its own perspective, and accordingly in a traditional communication environment much of the sense of the original communication can be lost. In addition, the range of potential linkages means that with traditional communication, information on the project as a whole is not collected in one central area. Finally, each party usually has its own project management systems – both manual and computer - which may have difficulty communicating with each other.

![Figure 1 Typical Communications – Construction Project](image)

The end result is that in a traditional communication environment, project information and the real message behind that information can be lost.

How well the large amount of information that needs to be shared among project participants is managed will have a large impact on the outcome of the project (Howell, 1996). Thus, in the traditional communication process, the project will suffer through lost information. On the other hand, good communication will have a positive effect on relationships between the parties to the contract, for the benefit of the project as a whole.

The ORCM process is designed to facilitate such good project communication, and so improve project management in areas such as time, cost, risk management and integration, resulting in improved project delivery.
Use of ORCM to Facilitate Project Communication

ORCM may be considered a development of “groupware”.

“Groupware” is the term used to describe computer software that is designed to support groups of colleagues (workgroups) attached to a local-area network to electronically organise and coordinate their activities. Current groupware tools (or group collaboration products) can include e-mail, calendaring and time management, videoconferencing and data conferencing (or application sharing).

The Internet/intranet explosion has focused attention on groupware because of the ease by which HTML pages can be created and shared widely. However, as electronic documents become widely used throughout the organisation, security and synchronisation problems surface. Document management becomes an problem, and access control and replication become issues. What starts out as a simple way to electrically publish information becomes as strategic as the client/server systems that have been distributed throughout the enterprise.

Groupware is becoming one of the critical issues in information technology – whether the applications be in finance, in retailing, in manufacturing, or indeed in design, construction and engineering (Crawford and Wilson, 2000).

ORCM in its current form supports document management, workflow management and transactions, which are three of the four areas (the fourth being full business-to-business interaction – a likely future development of ORCM) identified by Bjornsson (2000), into which Internet–based project management software and systems can be classified.

It is clear that ORCM, as an advanced form of groupware, fits within the long-term direction of electronic project management in a full electronic commerce environment, and is therefore likely to become a strategic tool in the drive to more effectively and efficiently deliver roadworks and other projects.

Figure 2 illustrates the use of ORCM to simplify project communication. This figure shows the communication flows resulting from a request for information from a sub-contractor. The left hand side of the figure shows the conventional communication and feedback channel from sub-contractor through head contractor to superintendent to designer (and possibly onto principal), and back again. The right hand side of the figure shows a transmission via an ORCM process, using a central shared file server.

As opposed to the serial transaction process of the conventional communication, the communication using the ORCM application is sent to an ORCM server and read from there by the designer. It is also available for viewing by other authorised parties. The designer can attend to the request immediately and simultaneously request comments and/or confirmation, including any necessary approval by the superintendent.

This parallel transmission and response process is clearly superior, from the time aspect, to the conventional serial process. Use of the central server also ensures that all project information is captured in the one location.
A further advantage of an ORCM process is that photographs and drawings can be readily attached to the transmission. The common bandwidth and network traffic related problem of not being able to attach large files to e-mails is solved through compressing larger files (some ORCM packages have automatic file compression and decompression algorithms built into them for this purpose) and transmitting these files through a file transfer protocol (FTP) process (thus spreading the transmission of large files over time, at a rate to suit the available network bandwidth).

**Implementation of ORCM**

Implementations of ORCM used in the Main Roads trials have to date consisted of two main software architectures:

- An extension to other systems, such as enterprise based project management software.
- Purpose built ORCM software.

ORCM installations may use either dial-up or Internet connections, or a combination of both. It is expected, however, that future implementations will increasingly make intelligent use of the Internet. Reasons include:

- The Internet can be used anywhere there is access to a telephone service, the only equipment required being computer with a web browser and a modem. Thus, parties can communicate across widely dispersed geographic areas.
Web browsers interface with almost all operating systems that use graphical user interfaces.

If remote storage Internet software is used, all communication files (and all other selected files) for the project can be stored at a remote location accessible by no single party, except through the Internet. This feature provides confidence in the system by all parties.

Messages and notices can be typed directly into Internet software, be recorded, and be made instantly available to all parties authorised to receive them.

Photographs, diagrams and other visual images can be easily incorporated in web software files, and made instantly available to viewers.

Web based software can allow the attachment of files in a range of formats, just as with e-mail. In addition, as previously discussed, the use of web based software allows the transmission of large files through limited bandwidth, through the use of techniques such as file transfer protocol, and compression and decompression.

Existing web supported technology provides the capability for holding virtual meetings between project participants.

The web facilitates interoperability between various platforms, and so has the potential to facilitate exchange between various software packages and lay the platform for integrated life cycle project development and management.

Observed difficulties in implementing web based systems are to be concerns with data security, integrity and related matters when using the Internet, and difficulty in obtaining reasonably priced local connections to Internet service providers in truly remote areas.

The ORCM Research Project

Research into the benefits and issues in implementing ORCM, including the security and remote area access matters described above, is being undertaken by the two year research project noted in the introduction to this paper. As stated in that introduction, this research project involves a partnership between academia, government and industry. A number of Queensland government agencies, including the Department of Main Roads, are participating in this research.

This research project has included an extensive Literature Review (Kajewski and Weippert, 2000), Technology Review (Crawford and Wilson, 2000) and Information Technology Analysis Framework (Kajewski, Weippert, Tilley, 2000).

The research will produce and use a range of measures, including performance measures and cost benefit analysis. While definitive results are not yet available, the research team has developed or adapted a number of methodologies for research, as illustrated in the Information Technology Analysis Framework described below.

Methodology for the Information Technology Analysis Framework utilise a similar framework to that for the Acton Peninsular Project in Canberra, Australia (Tucker et. al., 2000). Specifically, it examines IT implementation from seven perspectives:
For each perspective, subjective performance indices are selected on the basis of validity, reliability, stability, comparability, consistency and clarity, plus relevance to the particular perspective. This list of indices are weighted, for the particular perspective, using the Analytic Hierarchy Process (for example, Saaty, 1990).

A survey is formulated to measure the effectiveness of each perspective and administered at the early stages of each project (with results being used as a baseline), and at or close to completion, in order to identify and quantify the improvement in the effectiveness of the ORCM implementation. The survey results pertaining to each index are aggregated using the corresponding weighting factors, and presented on a Spider chart (see Figure 3 for an example), which serves as a graphical tool to demonstrate the trends of issues, results and benefits of implementing IT over the project duration (Kajewski, Weippert, Tilley, 2000).

The Queensland Department of Main Roads has introduced an additional research instrument for their trials of ORCM implementations. For these trials, the Department has developed a qualitative questionnaire aimed at eliciting the perceptions of those involved in the trial. Matters considered by the questionnaire include what has gone well and not so well, implementation issues, legal and administrative matters, suitability of ORCM for project communication, effect on project efficiency and relationships, and views on the future potential of ORCM.

**The Queensland Main Roads Trial of ORCM**

Queensland Department of Main Roads trial projects for the ORCM research project have included three sites, all located in Queensland, Australia as shown below. The first two of these sites used a purpose built ORCM product using Internet based communications. The third project (the Port of Brisbane Motorway) is a fairly new project using an enterprise based communications system.

- Dawson Highway, south of Emerald (the “West of Little Roundstone Creek” project described above);
- Brookstead to Pampas Reconstruction, Gore Highway, south of Toowoomba;
- Port of Brisbane Motorway Project – a major construction project in Brisbane.

Typical communications relationships (such as used at West of Little Roundstone Creek) were described previously (see Figure 1). The standard Departmental Road Construction Contract forms were converted to HTML format and were used for all standard correspondence.
Specific types of communication items used in this project (see Figure 4 for examples of the items to be handled by ORCM communications) included:

- General correspondence;
- Requests for information;
- Site instructions;
- Meetings and diaries;
- Photos and images.

The software used was a web based purpose built ORCM product developed in Australia. In addition to normal contract communications, this software also had the ability to manage quality records and project budgets (including progress payments and variations). Because other software was available for these purposes, the ORCM trial did not use these other facilities extensively. More extensive use of such facilities may well be considered in the future.

Figure 3  Performance Indices – Potential Trends over Project Duration  
(Kajewski, Weippert, Weippert, 2000)
For this project, software was leased from the supplier on the basis of a fee for project establishment, plus a weekly rental. Each participant, along with the participant’s personnel, was given a security profile. Messages were able to be delivered only to intended recipients. An automatically generated e-mail message was given to each recipient when a message was received. A log allowed viewing of system accesses, and recorded when messages were sent, received and opened.

At any time, a compact disk could be provided to any participant on payment of a fee to the software vendor. This disk was designed to list all communications by that participant, and the responses taken on receipt of those communications.

A feature of the use of ORCM in this project was its extension to providing public information through the use of web pages accessible to the public. These pages described and illustrated the project, discussed the reasons why it was being undertaken, and regularly advised of traffic conditions resulting from the performance of the works, or from weather conditions (such as temporary road closure through flooding).

During the main construction period of about six months, there were over 300 items of communication, of which about 80 per cent were general correspondence, and the remainder were distributed over meeting notices, calendar entries, task notifications, notice board postings, site instructions and standard contract notices.
A number of observations have been made from the operation of this site, and ORCM trials at other sites. These observations are discussed later in this paper.

As previously discussed, extensions of the ORCM trial were being considered, at the time of writing, to pre-construction and maintenance activities, the latter quite possibly using wireless technology, and preferably in a western District.

With pre-construction use of ORCM, it is envisaged that advantage be taken of Internet based communications to join a number of diverse parties with particular roles in the project, communicating (across the world if necessary) using visual images (and possibly voice) as well as written communication.

A likely application for using ORCM to assist maintenance is the potential use of real time conferencing between site and head office for problem resolution, using on-line digital video imaging of sites.

**Observations to Date**

As previously stated, research is continuing. However, a number of observations have been made. While the observations below are based on experience in the Queensland Department of Main Roads trials, they are likely to be quite generally applicable.

Perceptions of ORCM by the participants from the West of Little Roundstone Creek project, the only project on which detailed results are currently available, varied depending on the role of the participant in the project. A general conclusion would be that the perceived success or otherwise of an ORCM communication process is a function of a range of factors. Such factors include complexity of the project, ease of Internet access, computer literacy of participants, commitment of participants to an ORCM process, availability of alternative systems, training and the potential for saving travel and administrative time.

**Benefits**

The ORCM process is aimed at delivering the following benefits, a number of which have been discussed earlier in this paper:

- Improved efficiency in project and contract management.
- Better project control.
- Improved coordination of project operation.
- Faster reporting.
- Improved decision making.
- Better availability of information for project participants.
- Improved communication.
- Storage of project information in one location, thus promoting improved management of project knowledge and laying the platform for integrated life cycle project development and management.
- Improved contractual relationships as the result of better communication.

While research is still under way, observed benefits to date have included:

- Fast response times to correspondence, meeting acceptances, and the like.
• Ability to easily send one piece of correspondence to any one participant, or set of participants.
• Excellent document control, history of replies, comments, and the like.
• Document links (for example, linking contract variations to a budget module).
• Use of photographs to save time and money.
• Ability for transmission of drawings.
• Time savings to some project participants, and in particular those involved in managing the contract for the purchaser.

The process has the potential to be quite useful for very remote sites, provided reasonably affordable Internet or other electronic access (either by land link or satellite phone) can be obtained. For example, there is a time saving through the superintendent’s not having to travel to the site as often, and all participants have better knowledge about the project than in a conventional situation. There is also the potential for using video imaging, as discussed above. The ability to easily and cheaply obtain such access in remote areas remains a barrier to using the full potential of ORCM.

Use of the ORCM process has not abrogated the requirement for supervisors and others to visit sites. The process does, however, permit reduced travel requirements and thus time savings, particularly in more remote areas. It also allows personnel in remote offices to access project information quickly and easily, thus aiding improved decision making.

As discussed previously, a benefit which was not considered at the start of the ORCM project is the use of web-based systems to disseminate information about the project to stakeholders, including the public. Not only is information available on the web site about a particular project and why it is being undertaken, but also the public can be informed about any impact of works on travel conditions (such as road and traffic conditions through roadworks).

This feature can assist road authorities to improve public relations through advising travellers of roadworks, and should be able to aid in minimising traffic disruptions caused through roadworks projects.

The ability to store all project history available in one location is expected to aid future access to project records.

Issues

Issues in the uptake of ORCM technology have included:

• A comment from the qualitative questionnaire for the West of Little Round Stone Creek project was that the ORCM process is more suited to larger, more complex projects than to simple projects with straightforward communications. For such projects, more traditional communications such as telephone, facsimile and e-mail may suffice.
• There can be equipment and logistics difficulties, particularly on more remote sites. These difficulties include the availability of suitable equipment for some types of ORCM systems, delays in having telephones connected, not being able to have access to cost effective telephone services (either landline or mobile phones), and not having ready access to reliable Internet Service Providers.
• Internet access can be slow at times and not always reliable.
• Where organisations have standard document management systems, it may be necessary to
duplicate project history (for example, one copy on the ORCM system and one copy on
the local document management system).
• While considerable progress has been made in legal recognition of electronic
communications, and in prescribing how such communications should be managed from a
legal point of view, there is still much work to be undertaken in minimising risk in the use
of electronic transactions.
• Cultural issues, such as reluctance to change existing practices, may impact on effective
implementation.
• There is expense in implementing ORCM systems (although such expense is unlikely to
be a significant issue if the cost of ORCM is considered in the light of total project costs).
• Data security, integrity, authentication, verification, correctness, completeness, and the
like require to be considered.
• Participants require to be computer literate, and committed to the use of information
technology in project communications.
• Personnel who operate an ORCM system require training and practice.
• Use of ORCM does not reduce the need for well-trained, competent project management
personnel.
• ORCM is likely to be a less viable option where a project has been using established
management systems before the introduction of ORCM.

There are also a number of technical issues to be addressed, such as the available band-width
for data transmission, computer hardware and software compatibility and processing power,
and the cost of building and maintaining computer software.

Most of the issues discussed above are manageable, and many others will diminish with the
further development of information systems and communications technology, and the broader
acceptance of electronic communications.

The introduction of electronic transaction legislation is strengthening the legal position with
respect to electronic transactions. For ORCM transactions to be meaningful within the terms
of such legislation, it is likely that a number of contractual, system and other requirements
will need to be met. Such matters (such as suitable contract conditions, electronic signatures,
timing of communications, intellectual property, dealing with failure in the electronic system,
and the like) are likely to require close consideration in contracts, and the resultant risks
managed.

With legal and systems development assistance, the Queensland Department of Main Roads is
developing systems, procedures and suitable contract documentation to manage both the legal
requirements of electronic transactions and data security, integrity and related matters.

**Enabling Technologies for Extension of ORCM Capability**

Research has initially focused on written communication in construction. Its extension to
video conferencing using Internet capabilities, the use of hand-held devices and wireless
technology and to planning and design will require the use of technology which at the time of
writing has not yet been investigated in depth.

With respect to video conferencing, there are products that allow the use of a “virtual plan
room” concept, which allow virtual meetings to take place using the Internet. Such products
are able to make use of formal meeting procedures to keep the meeting flowing in an orderly manner. In addition, there is the ability to have an “electronic whiteboard” which allows the display of drawings, and the ability to write comments (using an electronic “pen” to write over the “whiteboard”). This type of software has been does not necessarily require the use of cameras and microphones.

A natural extension of the collaborative approach is the use of current and next generation mobile computer / communications devices. Such systems include mobile and wireless communications, global positioning systems and GIS capabilities, and may use techniques such as CAD, digital video, and photogrammetry. Such approaches could range from the more straightforward introduction of the handheld devices widely used in business as a personal organiser right through to wearable computing / communications devices.

Recent developments in telecommunications, digital photography and the like have the potential to extend this process into more remote regions, and therefore enhance its application to maintenance. Main Roads staff are currently investigating these developments in more depth.

Other new developments in this field include mobile phone devices, purpose produced handheld devices and advanced wireless technologies (Crawford and Wilson, 2000).

It is expected that with the implementation of such advances, the use of ORCM will become much more commonplace.

Discussion

It is clear that the electronic age is with us, and that in this age, advanced electronic communication will be a significant enabling technology in providing more effective and efficient delivery of roadworks projects.

This paper has presented one aspect of this coming change - the use of Online Remote Construction Management to facilitate communications between the participants in project delivery. This process is in its infancy at the moment. However, ORCM has the potential to foster better contractual relationships, develop the road construction industry and – through improved effectiveness and efficiency in the project delivery process – assist in delivering better roads at an optimum cost.

While at this stage benefits are still not being fully realised, the ORCM process has much potential to impact on the road development and management process. Areas that require further consideration include legal issues with respect to the use of electronic transactions, cultural issues, and the security and integrity of data. The associated risks require management, and appropriate processes put in place.

A relationship contracting environment is likely to facilitate use of ORCM and management of the risks.

In time, the ORCM process is likely to expand into pre-construction and maintenance. Use of Internet facilitated video conferencing, wireless transmission using hand held devices, and improved and faster internet access has the potential to facilitate this expansion, particularly in remote areas.
Future developments of this technology is likely to lead into the development of intelligent project delivery, with true business to business communication in the construction industry, integration of the supply chain, and a seamless development process from planning through design to construction and asset management.

Some of the technologies which potentially could be used include (in addition to wireless technology and videconferencing) integrated databases (including drawing databases and knowledge exchange), Computer Aided Design conferencing, use of virtual reality in designs, and simulation modelling (Kajewski and Weippert, 2000).

The QUT and CSIRO research project to implement, trial and evaluate ORCM, over a range of building and civil projects, should test the usage of ORCM in real situations, and assist in pointing the way forward to the world of intelligent project delivery.

Conclusion

Online Remote Construction Management is at the forefront of changes in the project delivery process. It has the potential to facilitate the exchange of information in planning, design, construction and maintenance management, aid in making quicker and better decisions, save cost and paperwork, and facilitate relationship contracting.

There are a number of issues to be yet dealt with, but they can be overcome. When these matters are overcome, the expansion of this enabling technology for gaining the benefits of construction process re-engineering, effectively using relationship contracting, integrating business processes, and fostering integrated life cycle project development and management is expected to facilitate the improved delivery of roadworks.
References


