RE-ENGINEERING THE CONSTRUCTION DELIVERY PROCESS

REPORT

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Cover photographs:

Norman River Bridge under construction. Qld Dept Main Roads.
Museum of Australia under construction. QUT-CSIRO Research Alliance.
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ACKNOWLEDGEMENTS

The CII Re-engineering Task Force acknowledges all those members of the construction industry who generously gave their time to allow the collection of case study data.

The task force also acknowledges the input of Professor Vernon Ireland for the facilitation of the industry Think Tank, Dr Albert Chan for expertise in statistical analysis and advice on compiling the report, and Professor Steve Rowlinson for assistance with case study analysis.
EXECUTIVE SUMMARY

The increasing complexity and sophistication of the construction industry has outstripped the ability of the logical but simplistic traditional procurement process to deliver major projects effectively. Industry reports and commissions of enquiry over the past sixty years have identified a multitude of problems and potential solutions. The industry has developed new procedures but these have tended to be piecemeal and reactive rather than proactive. We have been unable to find a “magic bullet” that will address all of the challenges in delivering projects.

This research project was led by an industry task force under the aegis of the Construction Industry Institute, Australia. The researchers developed a model and survey instrument following evaluation of previous work and the practical contemporary expertise of the team.

Ten case studies elicited fifteen project-related factors, which were critical to project success. These were:

- Co-operative project team
- Client’s competency and commitment
- Continuity of key personnel on the project team
- Well-defined functional brief
- Complexity
- Regular monitoring of key objectives
- Effective communication process
- Availability of suitable contractors
- Consultant selection criteria
- Mechanism for reward and penalty
- Clear reporting lines
- Client’s preparedness to absorb risk
- Shared responsibility to project problems
- Equitable risk allocation
- Selection of subcontractor

Stepwise multiple regression analysis identified four factors, which explained 64.9% of the overall performance variance. These results are consistent with the findings by other researchers. The four most important determinants of project success were found to be.

1. Co-operative project team.
   Elements such as commitment, trust, non-adversarial relationships and characteristics of teamwork engendered by approaches such as partnering and alliance contracting all contribute to a co-operative project team.

2. Clients’ competency and commitment.
   The Latham and Egan reports in the UK and the BCA report in Australia have emphasised the importance of client involvement in the project team. Such
involvement, particularly from experienced clients serves to minimise miscommunications on issues such as the brief, quality, time and cost priorities and so on. The client is able to facilitate decision-making, interpretation, strategic and tactical objectives.

3. Continuity of key personnel on the project team. This factor highlights the importance of developing and maintaining good working relationships. Also significant is the maintenance of the project “corporate memory” so that data are not lost and key decisions forgotten.

4. Equitable allocation of risk. Effective risk identification, analysis and management techniques together with equitable distribution to those parties best able to cope with the risk are now well-accepted as key determinants of successful projects.

The research team took these findings to a group of industry experts in a facilitated workshop with the aim of eliciting feedback for practical methods of progressing industry practice. The outcome of the workshop was a decision matrix focussed on six best practice guidelines that are relevant in today’s procurement industry to the determination and achievement of a project delivery process centred on maximising value to all the parties.

These are:

1. Value to parties – how to achieve value for all the project participants/stakeholders.

2. Alignment of objectives – break the cycle of mistrust currently driving the industry.

3. Holistic process – whole of life approach to project outcome, including a longer-term approach to shareholder value if applicable.

4. Value-driven selection process for all service providers is advocated over a purely price-driven process.

5. Eliminate duplication of effort – no ambiguity or confusion about roles or responsibilities.

6. Process not contractual arrangement – look at how to achieve high standards in key performance measures through fundamental process rather than through various existing contractual arrangements – recognise that expectations of high gain are likely to require high risks.

The decision support matrix is intended to be used by clients and consultants in developing a delivery method tailored to meet their particular needs. Often this will be similar to existing procurement methods but with additional components that ensure that each of the six fundamental principles are addressed.
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SECTION 1 Scope of Study

1.1 Introduction

The CIIA first established a Re-engineering Task Force in 1996 to examine the delivery options explored on Mobil Oil’s Port Stanvac Refinery in Adelaide\(^1\). Following this work a second task force was established with joint funding by the Australian Research Grants Council\(^2\) to undertake empirical research into opportunities for re-engineering the project delivery process. In 1999 the research project moved to Queensland University of Technology and the task force regenerated under the chairmanship of Bruce Cull of Leighton Contractors.

The procurement of constructed facilities is a process which involves many complex and interrelated steps. Along the way there are questions of value for money, probity and fitness for purpose. Over more than three centuries, the “traditional” process has been developed that focuses on clarity, separation of phases and a transparent independent bidding stage. Unfortunately there are some serious drawbacks. For example, the process can be inefficient and take a long time and often sets up opposing stances between the participants.

Although there have been many attempts to rationalise the process none has achieved notable success. However, in recent years other industries have managed to make significant gains in overall productivity by applying principles of business process re-engineering.

The principles of business process re-engineering focus on identifying inefficient and redundant steps in the supply chain as well as posing fundamental questions of the relevance and pattern of each step or element in the process.

This technique would seem to be particularly appropriate for application to the construction project delivery process and has been investigated by a number of agencies. At the same time, there is a willingness in industry to reopen the debate on process design.

This research attempted to address the key issues in the delivery process, which prevents the construction industry from realising the benefits enjoyed by other sectors from the application of new management techniques.

In essence, the question being asked by the task force is “how can we build and deliver a project to meet the client objectives and generate a return for participants in the most effective way?”

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\(^1\) Case Study reported as “Process Improvement Case Study and Procurement Selection” S.N. Tucker and M.D. Ambrose, Oct 1998.
\(^2\) ARC Collaborative Grant Number C39700422_2 “The Development of a Re-engineered Construction Project Delivery Process.” A.C.Sidwell
1.2 Background - The need for efficiency improvements in construction

There have been numerous inquiries into the efficiency of the building process, (Banwell 1964, RCBI 1992, BCA 1993, Latham 1994, Egan 1998) and most conclude that the characteristics of the engineering and construction industry which inhibit its effectiveness are organisational fragmentation, lack of co-ordination and communication between key parties, adversarial contractual relationships, focus on price rather than value, reduction in skills, inferior working conditions, industrial relations, and lack of customer focus.

A Federal Government study by Stoekel and Quirke (1992) identified that by comparison with other service industries, improvements in productivity in the construction industry will have a greater effect on lifting Australia’s Gross Domestic Product (GDP) than any other service industry. The study estimated that a productivity gain of 10% in the construction industry will lead to 2.5% increase in Australia’s GDP.

In the early 1990’s, the New South Wales Royal Commission into productivity in the Building Industry (Gyles 1992) identified inefficiencies in the Australian construction industry. Construction delays and cost overruns were in the order of 30% and there was a fear that this was discouraging overseas investors and business from building in Australia. In response, the Federal government established the Construction Industry Development Agency (CIDA) to stimulate industry reform.

The more recent DISR and NatBACC report (APP 1998) examined project delivery and procurement methods in order to identify approaches and models to enhance industry efficiency both locally and offshore.

The latter review of the industry confirmed that while the standard complaints of cost and time overruns, disputes and litigation, and production dissatisfaction are prevalent, project instigators and participants predominantly fall back to using or advocating systems that they are familiar with or that suit their own position. Most attempts at improvement have constituted embellishments or modifications to existing standard forms of delivery methodologies rather than fundamental review of project drivers.

Two Australian studies which have taken a broad view of the whole process are the T40 Report (Ireland, 1994) and a study of process improvement by Mohamed and Yates for the CSIRO (1995). Both studies modelled the building process and identified potential savings in time of between 25% and 40% by reducing non-value added steps in the process. More recent studies sponsored by the State and Federal Governments also provide guidelines to provide a more efficient and co-operative method of organising the project delivery process. Notably these are the Construction Queensland Report and Implementation Guide “Wealth Creation through Equitable Asset Delivery” (2001), and Case Study of the Acton Peninsula Development, (Hampson, Peters, Walker, Tucker, Mohamed, Ambrose and Johnston, 2001), and the ACA Report on Relationship Contracting, (2000).
The fragmented and differentiated structure of the construction industry is a major characteristic that militates against improvement. This is relevant in two respects. Firstly the fragmentation of the team as a whole, the client, designers, contractors, subcontractors and suppliers, and secondly the number of discrete trades and skills required to build a project. This multiplicity increases problems of communications and control and inhibits flexibility and innovation.

The challenge for the construction industry is to develop a radical project delivery process for the construction industry which concentrates on front end issues of procurement strategies, interfaces in the process, information flow, and the elimination of non value-adding activities. Why has this not been done before?

Breaking the mould will not be a simple task. The kernel of the traditional project delivery process is the adversarial contractual relationship, and the competitive tendering process. Owners have relied on the professions and the traditional process to safeguard their interests and ensure value for money.

In the public sector in particular the issue of probity quite rightly demands that the bidding process is transparent, in fact the critical control in most instances is the treasury departments. Now that an increasing number of public agencies are outsourcing their work the principles of competitive tendering and contracting are of even greater importance in achieving quality services and value for money to the community. Although the private sector is not constrained in the same manner, owners and their company boards are equally concerned that they receive value for money.

These studies, as well as lower profits, and initiatives taken by organizations such as CIDA have had a considerable impact in developing a culture of reform. The benefits of process improvement have yet to be realized by the construction industry in Australia.

Mohamed and Tucker (in McGeorge & Palmer, 1997: page 131) point out that an industry such as the construction industry represents a major challenge to Business Process Reengineering (BPR). This is mainly due to the complex business relationships which dominate the industry plus the key role external factors play in how construction industry organisations conduct their business.”

Can re-engineering be applied to an industry sector as a whole rather than to individual organizations? This is a challenge which has still to be addressed.

1.3 Research Objectives
The original objective was to develop a revolutionary project delivery process for construction by developing a benchmarking methodology, which would allow owners to select a contractor very early in the process, thereby eliminating the traditional detailed competitive bid.

However the analysis and case studies suggested that this approach tended to identify a solution before fully defining the problem. The research subsequently looked at
starting point and procedural factors and took on the process re-engineering principles of adopting a “clean slate” and questioning the rationale of existing processes in order to achieve innovations and fundamental change. The task force recognised the importance of taking a “big picture” overview, by placing greater emphasis on whole of life process issues.

1.4 Research Methodology
The research conducted by the CIIA Re-engineering Task Force comprised four main aspects: (1) review of the pilot study, (2) development of a generic model, (3) case study research through survey and interview, and (4) an industry think tank. The task force adopted the following process:

- Review the Port Stanvac Wharf pilot case study.
- Develop a framework or template to measure project success.
- Literature review and critique.
- Questionnaire focussing on project success factors and inhibitors.
- Questionnaire piloted on the successful project the Museum of Tropical Queensland in Townsville.
- Agree questionnaire format and data collection.
- Extend analysis of a selection of projects, both successful and unsuccessful.
- Data collection and analysis of data.
- Write up detailed case study report on each of the projects.
- Industry think tank conducted to review findings.
- Development of re-engineering methodologies.
- Review and publication of findings.

1.5 Case study projects
The CIIA Re-engineering Task Force looked at ten case studies to identify the processes and practices, which contribute to project success in terms of time, cost and quality. Primary research was done by the CIIA task force on eight of the cases. Information regarding the procurement process used on the Woodford Correctional Centre was derived from the paper "Innovative Project Procurement in the Queensland Government: The Woodford Correctional Centre," by Heldt, Hampson, Murphy, Wood, Deck, and Tucker, 1997.

Primary research on the Museum of Australia project at Acton Peninsula, Canberra was undertaken by the Construction Research Alliance (CRA) between QUT and CSIRO, with RMIT. (Hampson, Peters, et al, 2001)

The ten cases were:

1    The Museum of Tropical Queensland in Townsville
This project was selected as a very successful regional public building. It was procured by a design and construct method which delivered a high degree of value for money for clients and end users. The Statutory Authority responsible for procuring the building by-passed the Qld Department of Public Works and avoided a traditional lump sum process.
2 BACL’s multi-deck car park at Brisbane Airport
The contractor for this project was Barclay Mowlem Construction Limited who won the bid with an innovative alternative solution. The project was delivered ahead of time and within budget using a Design and Construction procurement system.

3 The Norman River Bridge, Normanton
This bridge project in a remote area of North Queensland was the first public sector/private sector project procured by alliance contracting in Queensland. The project was ground-breaking for the Qld Department of Main Roads and resulted in the highly successful delivery of a project with severe time constraints.

4 Pacific Motorway, Package 2, Yatala to Pimpama, South East Queensland.
The complex and technically demanding retrofit of a major highway to an existing corridor, under heavy traffic, was essentially a construct only contract. The project progressed under heavy time constraints. Queensland Department of Main Roads identified deteriorating relationships between the principal, superintendent and the contractor during the process and moved to install a relationship management unit.

5 Centre Block, Royal Brisbane Hospital
This $180 million project involved the procurement of a large-scale tertiary teaching hospital, 15-storey structure, 135m x 70m, including full fit-out. The construction phase was commenced in February 1998. Completion was achieved in July 2000, two months ahead of schedule by Bovis Lend Lease, Managing Contractor. Savings-sharing aspects of the managing contractor form of project delivery may have affected cost in use outcomes.

6 Browns Plains Interchange, Logan City
The project was procured by a traditional Schedule of Rates contract and was completed in December 1999, eight months ahead of schedule, by Queensland-based construction company, Bielby Holdings.

7 Optus Playhouse, Stage 5 Queensland Cultural Centre
A significant issue in the delivery of the Optus Playhouse was value for money for the Government and the tax-paying public. The building was procured by a traditional lump sum contract. The process delivered a high quality theatre. However, the project was characterised by cost and program increases due to a major scope change during the construction phase.

8 Neville Bonner Building at 75 William Street, Brisbane
The State Government client conducted a selected design competition for schematic design of a generic office building on a prominent site. The successful architectural team were novated to the Managing Contractor as were the client’s sub-consultants.

9 The Woodford Correctional Centre
The design of the Woodford Correctional Centre integrated technical requirements and operational philosophy such that design, construction and operational methodologies were inseparable in terms of the tender process. The project was procured by a private sector/public sector consortium.
The National Museum of Australia, Acton Peninsula, Canberra
This is a high profile public building, which was procured by alliance contracting. It was the first building project procured by this method and proved a highly successful outcome for all alliance partners including the owner, contractor, designer and sub-contractors.

The ten case studies are summarised in the following table:

<table>
<thead>
<tr>
<th>Project</th>
<th>Client</th>
<th>Contract type</th>
<th>Cost (AUS)</th>
<th>Completion date</th>
<th>Ahead/Behind Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Museum of Tropical Queensland</td>
<td>Queensland Museum Board</td>
<td>D &amp; C</td>
<td>$18.132m</td>
<td>January 2000</td>
<td>5 months early in 24 months</td>
</tr>
<tr>
<td>Carpark, Brisbane Airport</td>
<td>Brisbane Airport Corporation</td>
<td>D &amp; C</td>
<td>$12.165m</td>
<td>September 2000</td>
<td>8 weeks early in eight months</td>
</tr>
<tr>
<td>Norman River Bridge</td>
<td>Queensland Department of Main Roads</td>
<td>Alliance</td>
<td>$4.6m</td>
<td>December 1999</td>
<td>17 days early in 5 months</td>
</tr>
<tr>
<td>Centre Block, Royal Brisbane Hospital</td>
<td>Queensland Department of Health</td>
<td>Managing Contractor</td>
<td>$180m</td>
<td>September 2000</td>
<td>2 months early in 31 months</td>
</tr>
<tr>
<td>Optus Playhouse, QCC Stage 5</td>
<td>Queensland Performing Arts Trust</td>
<td>Traditional Lump Sum</td>
<td>$61m</td>
<td>July 1998</td>
<td>9 months longer than original 24 months</td>
</tr>
<tr>
<td>Browns Plains Interchange</td>
<td>Queensland Department of Main Roads</td>
<td>Schedule of Rates, with Partnering</td>
<td>$25m</td>
<td>December 1999</td>
<td>8 months early in 27 months</td>
</tr>
<tr>
<td>75 William Street Government Offices</td>
<td>Queensland Department of Public Works</td>
<td>Managing Contractor</td>
<td>$38m</td>
<td>1998</td>
<td>2 months early in 20 months</td>
</tr>
<tr>
<td>Woodford Gaol Queensland</td>
<td>Corrective Services Commission</td>
<td>Hybrid Managing Contractor</td>
<td>$54.8m</td>
<td>February 1997</td>
<td>6 weeks early in 18 months</td>
</tr>
<tr>
<td>Pacific Motorway Package 2</td>
<td>Queensland Department of Main Roads</td>
<td>Schedule of Rates</td>
<td>$135m</td>
<td>February 2000</td>
<td>9 months longer than original 18 months</td>
</tr>
<tr>
<td>Museum of Australia, ACT</td>
<td>Federation Department of Communication Information Tourism and Arts</td>
<td>Alliance</td>
<td>$155m</td>
<td>March 2001</td>
<td>On time</td>
</tr>
</tbody>
</table>

Table 1: Case studies characteristics summary
SECTION 2. Literature Review

The literature review was conducted in three main areas:
- Information concerning Business Process Re-engineering
- Information concerning Process Re-engineering in the construction industry context, and
- Information concerning the application of Process Re-engineering in the construction industry context.

2.1 Business Process Re-engineering

Re-engineering is the fundamental rethinking and radical re-design of business processes to achieve dramatic improvements in critical contemporary measures of performance such as cost, quality, service and speed. (Hammer and Champy 1993)

Re-engineering is also about creating and adding value in each and every activity within these processes and delivering the project to the level of customer expectation.

The results of this approach has certainly had a dramatic effect on some parts of the manufacturing sector with quantum improvements being made through the re-engineering process as illustrated in Table 2 below:

<table>
<thead>
<tr>
<th>Product</th>
<th>Before</th>
<th>After</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan Matsushita washing machines</td>
<td>360 hours</td>
<td>3 hours</td>
<td>99%</td>
</tr>
<tr>
<td>USA Harley Davidson motor cycles</td>
<td>360 days</td>
<td>3 days</td>
<td>99%</td>
</tr>
<tr>
<td>USA Motorola pagers – from inquiry to shipping</td>
<td>60 days</td>
<td>1 hour</td>
<td>99.8%</td>
</tr>
</tbody>
</table>

*Table 2: Examples of cycle time reductions after process re-engineering (Ireland 1994)*

Business process engineering means not just change but re-invention of an organization. BPR is not just looking for cost and timesavings or quality improvements in current operations – but questioning why operations exist.

Deming’s (1986) view of the re-engineered manufacturing process expresses important concepts which are not present in the traditional construction project delivery process.
- Customer focus,
- The cycle of consumer research leading to re-design,
- Relationship with suppliers, and
- The emphasis on quality throughout the whole process.
Michael Hammer is a leading advocate of Business Process Re-engineering. He argues that companies tend to utilise technology to mechanise, or computerise old ways of doing business. They leave the existing processes intact and use computers simply to speed them up. He says it is time to “stop re-paving the cow paths”.

According to Hammer (in McGeorge and Palmer, 1997: page 123) the essential characteristics of the re-engineering approach are:

- Recognition that an organisation’s core business is fundamentally “to service our clients”. Each member of the team must identify the customer as the *raison d’etre* for the organisation’s existence.
- A radical approach to problem definition and problem solving must be adopted. This means addressing the fundamental issues first rather than taking a fine-tuning approach to an existing process.
- The effect must show dramatic improvement – a quantum leap forward rather than continual incremental improvement.
- Re-engineering the process – not the organisational structure. Redesign of this process should be fundamental, radical and dramatic.
- High-risk – high gain expectations.

### 2.2 Process improvement in the construction industry context

In Hammer’s terms, the construction industry has been improving on systems that have existed for centuries, reshaping them, adding layer after layer. A fresh approach is possible only now that concepts such as benchmarking have achieved acceptance. This is coupled with the general reaction to the excesses of the 1980’s, the frenzy of claims and litigation, and the fear that if the construction industry does not radically change its *modus operandi*, it will remain as relevant as the dinosaurs. Belmote and Murray (1993) argue that “in the past, economic winners were those who invented new products. But in the twenty-first century sustainable competitive advantage will come more out of new process technologies and much less out of new product technologies”.

Construction industry goals are compatible with re-engineering goals but BPR is process based whereas the construction industry is traditionally project based. Manufacturing accepts that the production of a prototype costs more initially, but this cost is spread over thousands of units produced. In construction, each project is a prototype. What can the construction industry learn from this process? Deming (1986) believes that improvement of quality envelops the entire production line from incoming materials or services to the consumer and redesign of product and service for the future.

Process re-engineering or process improvement studies include investigation of the manufacturing industry because there are many similarities, which may bring useful lessons to construction. Adoption of manufacturing concepts could address crucial issues such as the integration of owner, designer, supplier, builder, procurement and production into one entity. Opportunities exist for reducing non-productive time
between the phases and for developing congruence of interest and motivation. Adoption of manufacturing concepts could also provide opportunities for improvement in relationships with suppliers, quality control and provide better working conditions and tenure for labour.

Love and Gunasekaran (1997a) assert that re-engineering attempts to change the mind-set, attitude and behaviour of organizations by fundamentally re-thinking and re-designing business activities, structures and working relationships in order to maximise added value and achieve sustainable improvement in all aspects of business performance.

It has been argued by Love and others that BPR can only be partially implemented into construction organisations because of the fragmented and heterogeneous nature of the industry. The suggested alternative proposal is one that implements re-engineering at a project level, utilising the concepts of a concurrent engineering, lean construction, process re-engineering and continuous process improvement. Construction Process Re-engineering (CPR) is this proposed alternative.

Mohamed (1997) suggested that CPR is not an easy concept to apply due to the complexity of the construction process and absence of innovative environments, which promote mechanisms for change in other industries. Ireland (1994) suggested that the conventional tendering system no longer lives up to the customer expectations and should be abolished. Ireland and the team involved in the T40 Study proposed an alternative project delivery method with a single point of accountability for both design and construction. Love and Gunasekaran (1997) reviewed the impact of four enablers, namely Information Technology (IT), organisational, human resources and total quality management (TQM) on CPR and argued that each enabler is interdependent and cannot be considered in isolation.

Table 3 below summarises the observations of McGeorge and Palmer (1997) regarding re-engineering applied to the construction industry.

<table>
<thead>
<tr>
<th>Essential Characteristics</th>
<th>Re-engineering Objectives</th>
<th>Applied to construction industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental</td>
<td>Identify and truly understand core business. “Why are we here?” “Why do we operate the way we do?”</td>
<td>Players in the industry must truly understand the nature of their business is to meet their clients’ expectations.</td>
</tr>
<tr>
<td>Radical</td>
<td>Make a considerable departure from the usual or traditional. Use lateral thinking.</td>
<td>Relate question to origin e.g. ask not “how can we minimise materials wastage on site?” Rather ask, “how can we redesign the process to eliminate waste?”</td>
</tr>
<tr>
<td>Dramatic</td>
<td>Achieve quantum leap forward rather than small continuous gains</td>
<td>Competing in an environment which is in a dynamic state of change</td>
</tr>
<tr>
<td>Process</td>
<td>Fundamental, radical and dramatic re-design</td>
<td>High risk, high gain expectations</td>
</tr>
</tbody>
</table>

Table 3: Re-engineering concepts applied to the Construction Industry.

2.2.1 The call for re-engineering the construction delivery process
Mohamed and Tucker (1996) reviewed the problems which led to the conclusion that the construction industry was in need of re-engineering.

Re-engineering the construction delivery process 17
• The industry is generally inflexible and unresponsive to the needs of its customers (Gyles 1992) because the complex structure which connects the wide range of industry partners and the existing adversarial relationships between architects, engineers, project managers, quantity surveyors, contractors, sub-contractors, and material suppliers has limited the ability of the industry to be innovative.

• Construction practice is dominated by fragmentation and conflicting interests. Participants form temporary organisations on a project-by-project basis and have different sets of goals and priorities.

• Performance is inconsistent and highly dependent upon circumstances associated with the project such as construction management effectiveness, client sophistication, and procurement system adopted.

• Major production principles do not always live up to customer expectations. The industry does not have a reputation of seeking customer’s satisfaction.

• Construction process consists of a large pool of interconnected activities carried out by different participants resulting in non-value-adding activities, which can add considerably to overall project time. (Ireland 1994)

• Extreme specialisation of activities points to a project management deficiency (Ireland 1994). Multiplicity of roles increases problems of communications and control and inhibits flexibility and innovation.

• Procurement systems are many and varied. Efforts to accelerate construction projects by overlapping design and construction activities fail because the focus is on parallel rather than integrated design and construction activities. (Huovila, Koskela and Lautanalu 1994)

2.2.2 Project procurement processes in Australia

The organisation of and project procurement processes in the Australian construction industry is largely derived from the United Kingdom where the traditional process which separates design and construction, and awards the construction to the lowest tenderer, has been developed over centuries, particularly since the industrial revolution. Under the traditional lump sum contracting system, the constructor agrees to complete the project as described in the documents at varying degrees of risk and a potential confrontation is commenced.

The traditional contract form does not support teamwork or collaborative relationships. The overall construction process is broken into a large number of small tasks, carried out by many specialist subcontractors. The consequence is lack of integration of the separate tasks and lack of innovation in the solutions provided because people only see the traditional narrow scope. (Ireland, 1994).

However the traditional process does have some notable characteristics which continue to hold relevance in today’s climate. These characteristics are best illustrated by the RIBA Plan of Work (RIBA 1980) which emphasises the step by step functional contribution and progressive definition, the output from each stage being the input to the subsequent stage. The clarity of this process is particularly attractive to clients who need to demonstrate probity.
Up to this time the industry has applied piecemeal solutions to improve the process, seeking efficiencies within each phase, such as standardisation, the imposition of codes of practice, use of computers, adoption of management tools from other industries, for example CPM, TQM, Partnering, JIT. In the past few decades the industry has developed procurement and contract management strategies to try to overcome some of the problems.

- **Construction Management** was developed in the 1960’s by the US construction industry to try to fast track the construction process, and was very popular on the North Sea Oil projects during periods of high inflation in the 1970’s. This method breaks a project into many packages of work, but can produce a construction manager with potentially little commitment to delivery of goods. (Sidwell and Ireland, 1987)

- **Management Contracting** was a hybrid of Construction Management, first developed by Arup Associates for the John Player factory in the UK in 1968, which took advantage of the contractor’s management ability while retaining competitive bidding for subcontractors. (Sidwell, 1983)

- **Design and Construct** places the accountability for the entire process firmly in the hands of one party, usually the contractor.

- **Novation** is a means of developing the design to a point where competitive bids can be sought, and then the successful contractor assumes responsibility for the completion of the design, a sort of controlled design and construct. (Chan, 1994)

- **Partnering** is an attempt to minimise adversarial relationships, mostly by developing trust and establishing agreed alternative dispute resolution techniques. It is a non-contractual approach.

If we accept Hammer’s concept of “re-paving the cow paths” then clearly the variety of process modifications adopted by the construction industry can be seen as merely solutions, which treat the symptoms of process dysfunction but not the cause, that is, “band aid” solutions.

Each of these strategies tackles at least one of the inefficiencies in the procurement process, but none take a holistic approach. Project Alliancing, a relatively new method of contracting that seeks to deliver a cost effective outcome within a set time frame through the project owner sharing risks and rewards with contractors. Success depends on a commitment to “best for project” behaviour from both the client and the commercial alliance partners. This approach has mainly been used in civil and mining projects but one major building project, the National Museum of Australia, Canberra, has been delivered using this strategy. (Hampson, Peters et al, 2001) Collaborative principles have recently been advocated in the Australian Contractor’s Association report on Relationship Contracting (2000).
2.3 Application of re-engineering in construction-industry context

2.3.1 T40 Report
Process re-engineering principles have not yet been adopted by the Australian construction industry. The T40 Report (Ireland 1994) is the most comprehensive study on the application of re-engineering principles to date. The intention was to produce a redesigned process and a series of new practices rather than simply complete present practices faster. The theoretical study modelled the building process and had the following major findings:

- Potential savings of 40% of the overall time duration,
- Possibility for more time savings through process redesign,
- Major causes of rework are design changes and quality deviations,
- Larger work modules should lead to more time savings,
- Co-ordination between subcontractors is currently at a minimum.

The current construction process was examined and an alternative solution developed. The T40 Report identified six key areas for change:

- Agreed common goals between customer and delivery team. The alternative process highlighted the need for all key implementation people in a construction project to be involved up-front to allow ownership of the goals by both customer and project team.
- Simplified process – single stage design and construction process with single point accountability and one subcontractor responsible for much more general activities encompassing numerous traditional activities.
- Re-engineered activities to overcome current inefficient fragmented arrangements and poor allocation of tasks. Fewer subcontractors to be responsible for larger component of works.
- Workforce commitment – the adoption of empowerment to the workers was considered important to make contributions to innovation on the project. The workforce should partake in the co-determination of issues.
- Partnering with local government to achieve speedy approvals on meeting pre-approved guidelines.
- Tendering replaced by selection of a contractor team on the basis of past record on time performance, agreed cost based on an adequately developed design, third-party endorsement of cost, agreed time for delivery significantly better than industry average, and public accountability. This process eliminates the cost to the industry and wasted effort of current tendering process.

The T40 research found that the reduction of subcontractors from 30-40 typically to 5 or 6 produced additional project costs of 3-5% initially due to the relearning required. However costs and times would be reduced by 25% and 40% respectively through practice. The T40 recommendations have not been adopted in their entirety by the construction industry as yet, though the National Museum of Australia Project on Acton Peninsula did provide a test-bed for many of the concepts.
Fig 1. Traditional Process and T40 proposed solution

The main stumbling block to change was the perception that the application of T40 principles would cost more than the traditional methods because of the relearning required. The T40 study team estimated that time would be reduced by 40% and costs by 25%. However, the T40 study also found that the reduction of subcontractors from numbering 30-40 typically, to just 5 or 6 produced additional costs of 3-5% initially. To date, no owner has been willing to pay this premium even though costs and times would be reduced through practice. The manufacturing sector accepts that the production of a prototype costs more initially but this cost is spread over thousands of units produced. In construction, each project is a prototype.

2.3.2 CSIRO Report
Mohamed and Yates (1995) applied three re-engineering concepts of concurrent engineering, lean production and process redesign to a tenancy fit-out work package for a typical office floor. They identified key success factors as prerequisites in implementing reengineering in a construction industry context. These reflect the importance of the human/communication factor to re-engineering.

- Strong commitment by major project participants to make a major shift in the workflow structure of design and construction.
- An effective communication cycle between major project participants helps to avoid rework and reduce time.
• Positive involvement of clients and end-users – resolve customer needs and business objectives.
• Quality assurance techniques to emphasize quality as value adding, rather than to concentrate on inspection and correction of defects.
• Innovations should be encouraged in areas of planning, contracting, design and construction.
• New approaches to improving construction output should be investigated.

2.3.3 CIIA Process Improvement Task Force – The Port Stanvac Wharf Case Study
The process improvement task force of the Construction Industry Institute, Australia was first established 1994/95 and re-established in 1996 following the identification of a case study for analysis and monitoring purposes. The objective of the task force was to evaluate issues affecting improvements to the project delivery process. The case study was Mobil’s Port Stanvac Wharf near Adelaide, South Australia, which was in need of replacement or refurbishment. The owners of the wharf implemented an innovative approach to assessing and choosing consultants and contractors for the project.

According to Tucker and Ambrose (1998), the focus of the research was to review the "front end" of the project delivery process, utilising the T40 research as a base, from opportunity identification until the start of construction with the objective of reducing project delivery time, cost and downstream rework.

Without prior knowledge of the T40 project, Mobil actually wanted to apply many of the ideas for improving the process. They sought to develop a close relationship with the team, to use partnering, and take full advantage of constructability by involving the constructor in the design process.

The design process involved the early use of consultants to assess the two main design solutions - to replace the wharf or refurbish the existing wharf - with one consultant handling each option. Both consultants worked with the same brief and were asked to provide initial cost estimates for their solution. The consultants were actively involved in the conceptual design including scope definition and these were incorporated into each of their final proposals. These solutions were then assessed by another external consultant, who advised that the replacement proposal was the most viable.

Mobil adopted the replacement option and the winning consultant developed a comprehensive bid package, which included detailed design development drawings. This was passed onto two preferred tenders who estimated the cost and outlined their construction process. Upon receiving the commission, the successful tenderer instigated an intensive three-day workshop to “lock down” the scope of work.

Design development took place over an intensive two-month period and culminated in a two-day value engineering workshop when all consultants and the client were brought together. It was towards the end of this process that a substantial overrun in budget was considered highly likely and, subsequently, Mobil decided to halt the
project and return to the refurbishment option, adopting a traditional design/head contractor arrangement for project delivery.

Nevertheless, the original process adopted was considered by many of the people involved to be very good. Indeed, the communication between client, contractors and consultants was excellent, yet the process failed to achieve the lowest cost solution.

However, the task force identified several key areas, which would need to be investigated further to establish their roles in contributing to the unexpected late change of options.

- importance of a definitive brief,
- impact of scope changes,
- scrutiny of basis of user input and its impact on costs,
- client/project (venture) team/consultant/contractor communication,
- role and timing of value management studies,
- impact of additional studies in middle of design development (e.g. mooring study),
- expectations of client and consultants - understanding and/or management of expected outcome,
- cost consequences of key changes,
- decision/approval check points,
- impact of possibility that the initial contractor estimate was too low.

The Port Stanvac project highlighted several areas, which can cause problems in the design development phase of a project. Of particular interest is the observation that a project delivery process, which appears to be working well, possessing many of the innovative techniques suggested by T40 and other such reports, can still fail to meet its objective.

It has even been suggested that parts of the process may have been working too successfully, in that the design team was working so well together and with such enthusiasm for the project, that they failed to step back and assess the consequences of their design solutions for the user requirements, particularly with regard to cost.
Whatever the reasons, the result demonstrates the importance of having in place process procedures which regularly check the progression of a project against established project criteria.

2.4 Conclusion to the Literature Review

Royal Commissions of Enquiry, government sponsored reform agencies, in depth research studies and industry reviews, in Australia and overseas, have identified and confirmed the need for an overhaul of the project delivery process. That no single satisfactory solution has yet been developed is testament to the complexity of the issue. Review of previous investigations and trials suggests some key elements in the development of alternatives and conduct of research. These are:

- the importance of maintaining the integrity of certain key steps in the process such as probity and risk management.
- improvements must come from industry initiatives else they fail practical tests.
- case studies provide fertile source of ideas and testing of new ideas.
- the procurement processes are merely the vehicles which embody fundamental relationship and procedural issues. It is these fundamentals which must be clarified and accommodated.
- there is no simple “one size fits all” solution.
SECTION 3 Research Methodology

3.1 CIIA Re-engineering Task Force Research Method

The CIIA Re-engineering Task Force was convened in 1999 to build on the work of a former CIIA Process Improvement Task Force, which evaluated issues affecting improvements to the project delivery process through a detailed case study report prepared on the Port Stanvac Wharf. The conceptual research model is shown in Figure 2.

A concept for a Re-engineered Project Delivery Process

Figure 2. Research model

The Re-engineering task force initially undertook a review of members’ views on the key issues facing the industry. This provided a focus for development of the model and subsequently the questionnaire.

Following review of literature including the Port Stanvac Wharf pilot study, the task force employed the following methodology to achieve the project aims. They:

- Developed a generic project model, which identified three broad elements, which make up a total project environment.
- Developed a questionnaire based on this model as a framework or template for data collection.
• Used the questionnaire to collect qualitative and quantitative data on ten selected retrospective case studies to determine common success factors and the various inputs critical to gaining this success, and any inhibitors.
• Conducted an industry ‘think tank’ to round off the investigation. Analysis of these findings can be used to determine critical factors required for a re-engineered project delivery process.

3.2 The Project Model

The task force reviewed existing models of project success and then developed a generic model as it interpreted the project environment, providing a framework or template to measure project success. This could be developed to gather data from many case studies and by statistical methods determine the level of importance of various factors and their interrelationships. The task force aimed to determine success factors and the various inputs needed to gain success, and any inhibitors, in order to determine critical factors required for a reengineered project delivery process, i.e. how to achieve inputs at an optimum level and how to eliminate inhibiting factors.

3.3 Questionnaire

The questionnaire was designed for an exploratory study, and included a large amount of material with the intention of examining a number of possibly important factors. The key areas investigated were generated from the model and included:
• Procurement strategies. Motivators in the procurement process – was the delivery method selected on systematic grounds? Establish the extent of the role of the client or other project participant in driving the procurement process. Were any radical processes adopted – what were the outcomes?
• Interfaces in the process. Teamwork and decision-making – what extent were various parties involved in decision-making, project development and project delivery processes. Any radical approaches to problem definition and problem solving?
• Information flow and data capture.
• Value-adding or elimination of non-value adding activities.
• Prevalence of the key concepts such as customer focus, consumer research, relationship with suppliers, emphasis on quality throughout the process.
• To what extent the budget and the brief influenced the outcome.
• What evidence of innovation in the process.
• Level of project success as measured by the level of satisfaction felt by various stakeholders.

The questionnaire was piloted on the people involved in the recently completed Museum of Tropical Queensland in Townsville.

The questionnaire was completed during interviews conducted with the main project team members involved in the delivery of each of the projects selected for study. This method of data collection was valuable in gaining qualitative information.

3.4 Case Studies – research method
The task force selected ten projects which had varying characteristics in order to provide a broad insight into the critical factors that contribute to project success or otherwise. Case study projects were selected using the following criteria:
- Representative of best practice projects.
- Representative of construction and engineering projects.
- Representative of scale and size from $5 million to $180 million.
- Relevance to future forms of construction and engineering work.

The task force employed these criteria, to assist to establish factors, which have a disproportionate effect on success and failure.

Information gathering commenced in September 2000 and continued until March 2001. Questionnaires were completed during face-to-face interviews, which were conducted with representative samples of project participants (project managers, client representatives, architects and other design consultants, clients, constructors and project cost controllers). Where necessary, follow up telephone queries or meetings were conducted. First draft cases were returned to respondents for checking and review. Subsequent alterations were received and incorporated if appropriate. Second draft cases were then returned for final review and approval.

3.5 Industry Think Tank
The think tank took the form of an intensive half-day focus group, using the nominal group technique. It was facilitated by Professor Vernon Ireland, currently CEO of Australian Graduate School of Engineering Innovation (AGSEI).

The think tank gathered together a combination of twenty-six participants from various sections of the construction industry with a combination of qualities.
including the ability to think laterally, extensive relevant experience, and enthusiasm about the subject. Participants included people from client organisations, contractor organisations and consultant organisations with expertise in both buildings and infrastructure projects.

The aim of the think tank was to elicit feedback for practical methods of progressing industry practice more broadly.

Think tank participants were called upon to discard entrenched ideas about project delivery systems and comparisons of existing delivery types and collaborate on brainstorming an effective model for successful project delivery that would:

- Take a sound principles-based approach.
- Be rational and unbiased toward any given segment of the industry.
- Be implementable.
- Produce improved results in application.
- Have wide acceptance.

Material circulated to participants prior to the meeting included:

- Outline of methodology pursued by the project task force.
- Process diagrams and summaries for ten case studies.
- An article by Vernon Ireland regarding the T40 project.

Brief details of the process followed at the workshop, the output achieved through the exchange of ideas, and three subsequent rounds of consultation with participants to select viable solutions in order to reach a consensus result are given in Section 6 of this report. A complete description of the Think Tank is provided in a separate report by Kennedy, 2001.
SECTION 4  Statistical Analysis

Factors Affecting the Success of a Construction Project

4.1 Introduction

Believing that “construction project success is repeatable” (Ashley et al., 1987, p.69), practitioners and researchers have paid much attention to establishing a set of factors contributing to project success. Chan et al (2001a) found that many empirical studies have been conducted to examine the impact of various project success factors. Ashley et al. (1987) and Pinto and Slevin (1988) are some of the pioneers in the identification and examination of critical success factors empirically in the 1980s. Jaselskis and Ashley (1991) explored how project managers could allocate scarce resources in an effective manner to achieve higher project performance. Sanvido et al. (1992) examined the contribution of factors such as project team experience, contracts, resources and information available to project success. Mohsini and Davidson (1992) tested the influence of a number of conflict-inducing organizational variables on performance of project using traditional procurement method. Tiong (1996) identified six critical success factors for build-operate-transfer projects. Most of these studies were conducted in the 80s and early 90s.

However, a number of new initiatives have been developed since the last decade (e.g. partnering and strategic alliance, benchmarking, construction process reengineering, etc.). The relevance of these early studies to the rapidly changing environment is debatable. This study, which examined projects that were completed in the last five years, was therefore conducted to address this gap. It aimed to (1) identify a list of important factors contributing to the success of a construction project, (2) categorize these project success factors into a smaller number of groups using factor analysis, and (3) examine the relative importance of these groups of factors on project performance.

4.2 Research methods

4.2.1 Data Collection

The data collection was based on a questionnaire survey, which was conducted between late 2000 and mid 2001. The questions concentrate on procurement strategies, information flow and value-adding activities. Although more than 40 respondents responded to this survey, they were drawn from the same ten projects recommended by the task force members. (Refer to Table 1 for list of the case studies).

4.2.2 Measures

Respondents were requested to rate most of the project success factors according to a five-point Likert scale (1=strongly disagree and 5=strongly agree). For those respondents who had no idea about the questions, they could leave the

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3 This analysis was undertaken by Associate Professor APC Chan
answer blank. Such an answer was treated as a missing value (Chan et al 2001a). Respondents were also requested to provide information about the overall performance in the project they involved (Question 5.6 of the main questionnaire). A similar five-point scale was adopted to reflect the performance (1=unacceptable, 2=poor, 3=average, 4=good, and 5=excellent).

4.2.3 Analysis
Respondents’ ratings were regarded as invalid if two answers were selected or no answer was indicated. Invalid answers were treated as missing cases and excluded from analysis. Factor analysis was conducted to reduce the fifty-six items (project success factors) into a smaller number of factors. Multiple stepwise regression was performed to explore the relative influence of the factors extracted from factor analysis on project performance. Similar analytical techniques were used by Chan et al (2001a) in assessing the performance of design/build projects.

Prior to factor analysis and multiple regression analysis, all variables of project success factors and overall project performance were examined for potential outlier and normality (Chan et al, 2001a). For the independent variables (project success factors), no univariate outlier was found since the standardized scores of all cases were within an acceptable range of $\pm 2.88$ ($p<0.004$, two-tailed test). Normality of all independent variables was checked by significant tests for skewness and kurtosis. The observed values of skewness and kurtosis were tested against the null hypotheses of zero because the values of skewness and kurtosis are zero when a distribution is normal (Chan et al, 2001a). The test statistics of skewness and kurtosis were within a range of $\pm 2.575$ ($p<0.01$, two-tailed test). Therefore, all independent variables were found to be reasonably normally distributed. The dependent variable (overall project performance) was also found to be normally distributed since the test statistics of skewness and kurtosis were within an acceptable range of $\pm 2.81$ ($p<0.005$, two-tailed test). No case of the dependent variable was considered as a univariate outlier since the standardized scores of all cases were within a range of $\pm 2.96$ ($p<0.003$, two-tailed test).

4.3 Results and Discussion

4.3.1 Factor Analysis of Project Success Factors
Principal factors extraction with Varimax rotation was performed through SPSS FACTOR program on 56 items of project success factors for a sample of 44 responses. The $\chi^2$ test statistic of Bartlett’s Test of Sphericity was significant at $p<0.001$, which indicated that all correlations were significantly different from zero. Factor loadings, percent of variance explained and cumulative percent of variance explained are shown in Table 4.
### TABLE 4. Factor Structure for Principal Factors Extraction and Varimax Rotation on Project Success Factors Items

<table>
<thead>
<tr>
<th>No</th>
<th>Item</th>
<th>Factor loading</th>
<th>Percent of variance explained</th>
<th>Cumulative percent of variance explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td></td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>4.22</td>
<td>Relationship between the project team leadership and members of the project team</td>
<td>0.899</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.4</td>
<td>Project team dynamics</td>
<td>0.849</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.13</td>
<td>Style of conflict resolution</td>
<td>0.819</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.12a</td>
<td>Team culture with respect to level of trust</td>
<td>0.811</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.7</td>
<td>Members of the project team’s willingness to be cooperative with each other</td>
<td>0.761</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.12b</td>
<td>Team culture with respect to level of ethics</td>
<td>0.741</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.20</td>
<td>Effectiveness of the organisational structure and the delegation of authority</td>
<td>0.731</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.15b</td>
<td>Level of communication within the project team</td>
<td>0.698</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.12d</td>
<td>Team culture with respect to turf protection</td>
<td>0.653</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.12c</td>
<td>Team culture with respect to risk allocation</td>
<td>0.618</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.21</td>
<td>Relationship between the client and project management team</td>
<td>0.603</td>
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<td></td>
</tr>
<tr>
<td>4.16</td>
<td>Project team’s responsiveness to client requests and questions</td>
<td>0.575</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.8</td>
<td>Project team’s flexibility /ability to adapt</td>
<td>0.541</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.15a</td>
<td>Level of communication between the client and the project manager</td>
<td>0.524</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.12g</td>
<td>Team culture with respect to the reliance on the contract</td>
<td>0.520</td>
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<tr>
<td>4.12f</td>
<td>Team culture with respect to the information management</td>
<td>0.502</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.12e</td>
<td>Team culture with respect to team chemistry</td>
<td>0.465</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.14</td>
<td>Project team’s willingness to look for better ways to do things</td>
<td>0.465</td>
<td>24.516</td>
<td>24.516</td>
</tr>
</tbody>
</table>

**Factor 1: Cooperative project team**

4.1 | Client’s corporate value system                                      | 0.861          |                               |                                           |                                          |
4.2 | Client organisation’s attitude/commitment to the project             | 0.534          |                               |                                           |                                          |
2.9 | Client’s capacity to be part of an integrated project team           | 0.518          |                               |                                           |                                          |
4.3 | Leadership role on the project                                       | -0.437         | 6.905                         | 31.422                                   |                                          |

**Factor 2: Client’s competency and commitment**

4.10c| High level of continuity on the project team in terms of key personnel | 0.881          |                               |                                           |                                          |
4.10d| High level of continuity on the project team in terms of suppliers   | 0.868          |                               |                                           |                                          |
3.3a | The form of contract adopted in the project                          | 0.633          | 6.639                         | 38.061                                   |                                          |

**Factor 3: Continuity of key personnel on the project team**

4.10a| High level of continuity on the project team in terms of contractors’ project manager | 0.766          |                               |                                           |                                          |
1.5  | Complexity of the project                                            | -0.696         |                               |                                           |                                          |
2.6  | Level of technology incorporated into the project                     | -0.617         |                               |                                           |                                          |
4.10b| High level of continuity on the project team in terms of client’s representative | 0.535          | 5.309                         | 49.796                                   |                                          |

**Factor 4: Well defined functional brief**

3.1e | Well defined brief in terms of time for completion                   | 0.809          |                               |                                           |                                          |
3.1a | Well defined brief in terms of functional                            | 0.747          |                               |                                           |                                          |
2.12 | Influence of external constraints - politics                          | 0.476          |                               |                                           |                                          |
4.10c| High level of continuity on the project team in terms of consultants  | -0.361         | 6.427                         | 44.487                                   |                                          |

**Factor 5: Complexity**

5.3  | The key objectives were reported on a regular intervals              | 0.886          |                               |                                           |                                          |
5.2  | Clear identification of key objectives at the beginning              | 0.640          |                               |                                           |                                          |
5.4  | Project performance was monitored soon after project completion      | 0.594          | 4.428                         | 54.224                                   |                                          |

**Factor 6: Regular monitoring of key objectives**

4.18 | Effective communication process to eliminate re-work                | 0.674          |                               |                                           |                                          |
2.11 | Influence of external constraints - community                        | -0.661         |                               |                                           |                                          |
4.9  | Impact of previous experience on project success                     | 0.658          |                               |                                           |                                          |
4.19 | Effective communication to avoid delays                              | 0.583          | 4.242                         | 58.466                                   |                                          |

**Factor 7: Effective communication process**

2.5  | Physical complexity                                                 | 0.837          |                               |                                           |                                          |
2.11 | Availability of suitable contractors with proven relationship        | -0.502         | 3.780                         | 62.246                                   |                                          |

**Factor 8: Availability of suitable contractors**

4.23 | Criteria upon which consultants were selected                         | 0.837          |                               |                                           |                                          |
3.1c | Well defined brief in terms of budget                               | 0.614          |                               |                                           |                                          |
3.1b | Well defined brief in terms of technical requirements                | 0.565          | 3.558                         | 65.805                                   |                                          |

**Factor 9: Consultant selection criteria**

4.26 | Mechanisms which provided reward for performance                    | 0.913          |                               |                                           |                                          |
4.27 | Mechanisms which imposed penalty of non-performance                  | 0.889          | 3.359                         | 69.163                                   |                                          |

**Factor 10: Mechanism for reward and penalty**

4.17 | Clearly defined reporting lines within the project team              | 0.879          | 2.961                         | 72.124                                   |                                          |

**Factor 11: Clear reporting lines**

4.25a| Risks were contracted out regardless of capability to manage and absorb impact | -0.826         |                               |                                           |                                          |
2.10 | Client’s preparedness and capacity to absorb risk                    | 0.570          | 2.734                         | 74.858                                   |                                          |

**Factor 12: Client’s preparedness to absorb risk**

4.25c|Risk management was a total team responsibility                        | 0.843          |                               |                                           |                                          |
2.7  | Project sensitivity to disruption by cultural heritage or environmental issues | 0.562          |                               |                                           |                                          |
5.5  | Lessons learned from the project were formally fed back for future  | 0.426          | 2.520                         | 77.378                                   |                                          |

**Factor 13: Shared responsibility to project problems**

4.25b| Risks were allocated to the party most able to take                   | 0.896          |                               |                                           |                                          |
3.1d | Well defined brief in terms of operational costs                      | -0.453         | 2.217                         | 79.595                                   |                                          |

**Factor 14: Equitable risk allocation**

4.24 | Criteria upon which subcontractors were selected                     | 0.774          | 2.177                         | 81.771                                   |                                          |

**Factor 15: Selection of subcontractors**
Fifteen factors were extracted and altogether accounted for 81.77% of the variance in responses. The first three factors accounted for 24.52%, 6.91% and 6.64% of the variance respectively. Most factor loadings were greater than 0.5, and 23 of them were greater than 0.7. In general, the loadings and the interpretation of the factors extracted were reasonably consistent. The meaning of the fifteen factors were interpreted as follows:

Factor 1 – Cooperative project team
This factor consists of 18 items, which focus mainly on teamwork and project participants’ relationship. Cooperative project team includes the relationship between the project team leadership and members of the project team, project team dynamics, style of conflict resolution, members’ willingness to be cooperative with each other, effectiveness of the organisational structure and the delegation of authority, level of communication within the project team. Team culture with respect to level of trust, ethics, turf protection, risk allocation, reliance on the contract, information management and team chemistry is also an important item within this factor. Apart from these common capabilities, project team should be responsive to client’s requests and questions, willing to look for better ways to do things, and be flexible to adapt.

Factor 2 – Client’s competency and commitment
This factor has four items with emphasis on the client’s corporate value system, client organisation’s attitude/commitment to the project, client’s capacity to be part of an integrated project team. Client’s leadership role on the project is also included in this factor.

Factor 3 – Continuity of key personnel on the project team
This factor includes three items. Its main focus is to on the assessment of the level of continuity on the project team in terms of key personnel and suppliers. The form of contract adopted in the project is also included in this factor.

Factor 4 – Well defined functional brief
This factor has four items with emphasis on a well-defined brief in terms of time for completion and the function of the project. Influence of political constraints and the consultant’s level of continuity on the project are also included in this factor.

Factor 5 – Complexity
This factor has four items, which focus on the complexity and the level of technology incorporated into the project. Contractor and client representative’s level of continuity on the project are also included in this factor.

Factor 6 – Regular monitoring of key objectives
There are three items in this factor. These items examine whether the key objectives were reported on a regular interval, whether key objectives were identified at the beginning, and whether project performance was monitored soon after project completion.
Factor 7 – Effective communication process  
This factor has four items, which focus on the communication process inside and outside the project team. Inside communication process attempts to measure how effective it is to eliminate re-work and avoid delays. Outside communication process aims to measure how effective it is to communicate with the community and feed back previous experience to future projects.

Factor 8 – Availability of suitable contractors  
This factor has two items with emphasis on the physical complexity and its effect on the availability of suitable contractors with proven track record.

Factor 9 – Consultant selection criteria  
There are three items in this factor. These items focus on the criteria upon which project consultants were selected. Well-defined brief in terms of budget and technical requirements are also included in this factor.

Factor 10 – Mechanism for reward and penalty  
This factor has two items, which examine the provision of reward and penalty mechanisms in the project.

Factor 11 – Clear reporting lines  
This factor contains only item which looks at the reporting lines within the project team.

Factor 12 – Client’s preparedness to absorb risk  
There are two items in this factor. These items examine the way that the risks were contracted out, and client’s preparedness to absorb risk.

Factor 13 – Shared responsibility to project problems  
This factor contains three items, which consider whether risk management was a total team responsibility, whether the project was sensitive to disruption by cultural heritage or environmental issues, and whether lessons learned from the project were formally fed back for future projects.

Factor 14 – Equitable risk allocation  
This factor has two items, which examine whether risks were allocated to the party most able to take, and whether there was a well-defined brief in terms of operational costs.

Factor 15 – Selection of subcontractor  
There is only one item in this factor. This item looks at the criteria upon which subcontractors were selected.

These fifteen factors represented the important areas that all project stakeholders should focus on. The capabilities and the commitment of client to achieve outstanding project performance were clearly reflected in Factors 2, 4 and 12. The willingness of all project participants to work in a coherent manner was reflected in Factors 1, 13, and 14. The need for a proper communication and monitoring mechanism was reflected in Factors 6, 7, 10, and 11. The importance of adopting a proper selection process in engaging key project personnel was reflected...
in Factors 3, 8, 9, and 15. Factor 5 indicated that project performance was also affected by the complexity and the technology incorporated into the project.

Although these fifteen factors may not cover all aspects of project success, they collectively accounted for various important project success elements. Additionally, these factors were examined empirically by a multivariate analysis – factor analysis. It is expected that these fifteen project success factors can lay a foundation for future project evaluation research. More empirical testing of the factor structure observed in this study should be conducted.

4.3.2 Stepwise multiple regression results

A stepwise multiple regression was conducted between the overall performance of project as the dependent variable and fifteen project success factors as the independent variables using SPSS REGRESSION program. Fifteen factor scores for each respondent were calculated using regression method in SPSS. These factor scores formed the data set for the stepwise multiple regression analysis. An entrance criterion that an $F$ statistic must be significant at the level of 0.01 was set. Table 3 shows the standardized regression coefficients ($\beta$), the intercept, $R^2$, $R^2$ change, and significant level ($p$). Eleven factors were excluded from the regression model because they failed the entrance criteria. The standardized regression coefficients of cooperative project team (factor one), client’s competency and commitment (factor two), continuity of key personnel on the project team (factor three), and equitable risk allocation (factor fourteen) were differed significantly from zero at $p \leq 0.018$. Altogether, 64.9% of the overall project performance variance was explained by these four factors. Cooperative project team contributed significantly to prediction of overall project performance ($R^2=0.29, p<0.001$). Client’s competency and commitment, continuity of key personnel on the project team, and equitable risk allocation accounted for 18%, 12%, and 6% of variance in the overall performance respectively.

<table>
<thead>
<tr>
<th>Independent variable (Critical success factors)</th>
<th>Standardized Coefficients ($\beta$)</th>
<th>$p$</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1: Cooperative project team</td>
<td>0.540</td>
<td>0.000</td>
<td>0.292</td>
<td>0.292</td>
</tr>
<tr>
<td>Factor 2: Client’s competency and commitment</td>
<td>0.424</td>
<td>0.001</td>
<td>0.472</td>
<td>0.180</td>
</tr>
<tr>
<td>Factor 3: Continuity of key personnel on the project team</td>
<td>0.348</td>
<td>0.001</td>
<td>0.593</td>
<td>0.121</td>
</tr>
<tr>
<td>Factor 14: Equitable risk allocation</td>
<td>0.235</td>
<td>0.018</td>
<td>0.649</td>
<td>0.055</td>
</tr>
<tr>
<td>Constant</td>
<td>4.591</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Dependent variable is the overall project performance.

The multiple regression results were consistent with the findings of past studies (Ashley et al., 1987; Pinto and Slevin, 1988; Mohsini and Davidson, 1992; Songer and Molenaar, 1997; Chan et al, 2001a; 2001b). Cooperative project team
was shown to be the most important factor contributing to overall project success. The results tallied with Jefferies’s et al. (1999) survey findings of factors perceived to be important to successful teaming (ability of team to resolve conflicts quickly, establishing mutually agreed goals early in the project process, and trust exists between team members). This project success factor also represented some key elements of partnering — commitment to respect, trust, and cooperation (Cowan et al., 1992), and dedication to common goals (Hancher, 1989). Through the recognition and respect of all parties’ goals, momentum towards project success is created (Moore et al., 1992). In fact, a number of previous studies regarded partnering as an effective dispute resolution strategy and a commitment to achieve project success (Ng and Mo, 1997; Chan et al., 2001b). Nevertheless, one should not equate teamwork with partnering (Chan et al, 2001a). Partnering involves the development of a long-term relationship and commitment among the partners, while teamwork does not necessarily have this characteristic (Albanese, 1994).

As indicated by the regression findings, a client’s competencies in managing projects were found to be the second key factor contributing to overall project success. Although researchers and practitioners have heavily emphasized the role of the contractor (Chan, 1996; Walker, 1994), the position held by the client is by no means trivial. Rather it was shown in the findings that the client played an even more important role than contractor. Since the design team relies mainly on the client’s brief to develop design, unnecessary misunderstanding, conflicts and delay easily arise if ambiguity and error exist in client’s brief. Given the fact that the client would be expected to understand end-users’ requirements much better than other project participants, client’s contribution to the briefing process is great. Active client involvement in the early stage of project enables the client to get a thorough understanding of the project scope and articulation of end-users’ needs. Changes to the project scope and end-users’ needs could be reduced with an effective briefing process (Chan et al, 2001c). Obviously, the client’s input into the development of a clear project brief, which reflects project requirements accurately, is critical to project success (Murray, 1995).

The third factor contributing to project success was the continuity of key personnel on the project team, which tallied with the findings of Ashley et al., (1987; Chan et al 2001a). Continuous working relationship is particularly important to project success in developing countries where well-qualified contractors are insufficient (Mo and Ng, 1997). Project team members’ expertise in similar facilities is important for some uncommon projects (e.g. some Navy installations) (Emmons, 1995). Clients should recognize that project team formation would be hindered if members were operating on tight profit margins and unrealistic deadlines (Jefferies et al., 1999).

The fourth factor, which contributes to project success, is the equitable allocation of risk. The construction industry is subject to more risks than other industries (Thompson and Perry, 1992). Project risk management has a significant effect on project success (Flanagan and Norman, 1993). Project risk management includes the processes concerned with identifying, analysing, and responding to project risk (PMI, 1996). It includes maximizing the results of positive events and
minimizing the consequences of adverse events. Ward (1999) advocated that an effective risk management process is associated with the context and the characteristics of the participants. Risks should be equitably allocated to a party who is most capable of managing the risk (Turner, 1999).

4.4 Conclusions

Fifteen project success factors were extracted by factor analysis on 56 variables developed through a synthesis of empirical studies and project participant’s opinions. These factors formed the basis for project evaluation. Four of them were found to be critical in explaining the overall project performance from the multiple regression results. All these factors highlight that project success rests on the commitment of and efforts input by all parties to the project. Specifically, these were: (1) a cooperative project team, (2) client’s competency and commitment, (3) continuity of key personnel on the project team, and (4) equitable risk allocation.
Section 5 CASE STUDY ANALYSIS

5.0 Introduction

Over the past decade, the contracting environment has become very complex. Traditional delivery systems are often inadequate to achieve good results across financial and delivery performance requirements, and to address the diverse needs and higher performance expectations of stakeholders.

The projects studied represent a range of types including construction and engineering projects and a range of scales from the $5,000,000 Norman River Bridge to the $180,000,000 Ned Hanlon Building, Centre Block at the Royal Brisbane Hospital. The approaches to project delivery varied widely from traditional schedule of rates to full project alliancing. However, a feature of all the projects was the high degree of commitment demonstrated by clients to achieving successful outcomes. The importance of the right person for the job and maintaining good relationships within the project team was also emphasised. Dissatisfaction with fee levels for consultants and inadequate documentation were also recurring themes. The relationship between risk and rewards to the various parties involved in delivering construction projects is also significant.

This section represents a summary of the distinctive features of each case studied in the course of this research project. It is presented as an analysis of commonalities amongst the cases and discusses lessons which may be learned.

5.1 Case Studies Summarised

5.1.1 The Museum of Tropical Queensland in Townsville

This project demonstrates the validity of an alternative delivery method and illustrates how a co-operative and trusting approach to project development can add to project success.

Queensland Treasury allocated the client, the Queensland Museum Board, a fixed budget. In order to achieve the best possible value for money, and avoid the pitfalls of traditional lump sum contracting, the Board proactively sought alternative delivery methods and called for tenders for a “total delivery system”.

The Board selected the Leighton Consortium to undertake total project delivery using an innovative Design and Construct contract which included a go/no go decision point for client.

Both the client organisation and the design and construction consortium identified the following key contributors to the project’s success:

- Clearly articulated client needs. The well prepared brief was a critical document and remained a strong point of reference throughout the delivery process. The parties agree that this document translated to budget and schedule performance.
• Trust and co-operation was present between the parties to the contract. The client and the contractor consortium saw themselves as members of the one team, with mutual objectives.
• Open lines of communication between the partners ensured there were “no surprises”.
• Risk was shared appropriately between the parties.
• Project team participants were selected on the basis of factors other than price such as suitability for the job.

The fundamental advantages of the delivery process used on this project were:
• The fixed budget allowed tenderers to compete on design quality and skilful management rather than price. The Leighton Consortium included a high-profile award-winning architect of public buildings whose role was to deliver a solution, which not only satisfied, but added value to the client’s brief. The considered architectural solution delivered strategic value-added benefits, which were beyond the client’s initial expectations.
• The client and the community benefited from the design management skills of the preferred consortium in terms of the end product.
• The open book financial system, where the contractor’s profit margin is known at the outset, encouraged the builder to take on the spirit of the project rather than to try to “do even better”.
• The point of satisfaction strategy introduced by Leighton Consortium allowed the client to obtain a suitable outline design prior to formally assigning documentation and construction risk to the contractor. This was essentially a go/no go decision point.
• The contractor clearly understood the scope and nature of the necessary building works prior to agreeing to a Fixed Price Contract Sum.
• Disputes, contractual or industrial, did not arise.

5.1.2 BACL’s multi-deck car park at Brisbane Airport
The project to build a long-term car park at the airport was delivered ahead of time and within budget using a Design and Construct procurement system. The contractor was Barclay Mowlem Construction Limited who won the bid with an innovative alternative solution.

The client originally developed a concept scheme and sought Design & Construct tenders on this scheme. However, they also invited non-conforming tenders on the proviso that tenderers submit a conforming tender as well. This strategy had the effect of delivering a demonstrably better solution with value-added attributes for the client.

Barclay Mowlem’s winning submission exceeded BACL’s initial expectations of what could be achieved for their budget and within their stipulated time frame. The contractor identified an alternative approach that provided more car spaces and more of them undercover, while fulfilling the client’s business needs pertaining to continuous operation of the existing car park. Barclay Mowlem did not seek
competitive bids within their own project team thus establishing a trusting relationship with their design consultants from the outset.

Key contributors to project success were identified as teamwork and a non-adversarial approach:

- The client had confidence in the Barclay Mowlem team.
- The client valued the contractor’s previous experience, level of commitment and dedication.
- A high level of trust between client and contractor resulted.

Other factors that contributed significantly to the success of the project were:

- Continuity of team members for the life of the project, and
- The client sought to link the design solution to whole of life maintenance issues through warranties; subsequently, the project team were very proactive in seeking better solutions for better outcomes.

Off-setting the gains to the client was the cost to industry in general of the contractor selection process adopted for this project. Several rounds of short listing, and the final five short listed contractors required to make detailed submissions on two schemes was very costly in terms of time and expense to the contractors as well as to the numerous consultants who would have bid fees.

5.1.3 The Norman River Bridge, Normanton

Outstanding results were gained for Queensland Department of Main Roads in this, the first public sector project procured by alliance contracting in Queensland. Main Roads formed an alliance with private sector construction company, Barclay Mowlem Construction Ltd. The main driver for selecting the alliance approach was the difficult time constraint of procuring a new bridge in a remote part of north western Queensland that is subject to flooding in the “wet” season each year. Work could not commence before the floods receded in March and had to be complete before the onset of the monsoonal weather in the following December.

Key contributors to project success were:

- The two entities’ goals were closely aligned in a high risk/high reward environment.
- Financial incentive for co-operation was underscored by the “best for project” approach which required substantial will and enthusiasm on the part of the participants.
- Executive management supported collaboration and the matching of corporate cultures by appointing appropriate personnel to the project team.

Advantages of the alliancing delivery system were:

- All decision making for the project was the responsibility of the Alliance Board, comprised of two members from each partner, who met on site regularly.
- Open book financial system operated of necessity.
- The project was delivered on time.
In this project, supply chain relationships were identified as an area where process improvements could have been achieved. A major sub-contractor was not an alliance partner and thus was not motivated to co-operate with the Alliance in achieving their goals. The sub-contractor was offered a bonus for completion as an incentive.

The project passed a Public Works Committee enquiry into the procurement of the bridge, which concluded that value for money had been achieved. The parliamentary committee was satisfied with the procurement methods used in the project and with the balance of public and private sector involvement for the work.

5.1.4 Centre Block, Royal Brisbane Hospital
This large-scale project on a crowded city fringe site was procured by the Managing Contractor form of contract developed by the Qld Dept of Public Works to procure Queensland Health’s building programme.

The Principal required a degree of flexibility to be able to make changes if evolving health services policy changes dictated it. The selected project delivery system met this requirement.

Overall project performance on the Centre Block project was extremely high. The client body felt that the Managing Contractor approach to procurement allowed an appropriate degree of client interface.

However, aspects of the contract form may have affected long term operating outcomes. Savings-sharing clauses may have given the wrong incentive to find savings where no feasible savings existed.

Key issues which contributed to success in the delivery of this project were:
- Clear Objectives.
  Health projects have traditionally been plagued by changes. A major objective in the delivery of the Centre Block project was that there would be no significant changes during the procurement phase. The Functional Brief and Project Definition Plan was developed at the commencement of the Centre Block project with extensive user input. The strict management of user requirements was a critical component of the success of this project.

- Project personnel.
  Experienced project team members played a significant role in project success. The high level of professionalism which each of the project participants brought to the project was a major factor in the successful outcome.

- Roles and responsibilities clearly defined.
  Parties understood their project procurement responsibilities under the contract. Requirement changes were effectively limited and an effective monitoring and approval mechanism for design changes was established.
Reasonable Risk Allocation.
Both parties to the main contract felt that financial risk was allocated to the party most able to manage this risk. The savings-sharing clauses provided the incentive to Bovis Lend Lease to deliver the project within budget, within program and to the required quality. Whilst the contractor’s risks were high, their expectations of gain corresponded with this.

Design and documentation.
Realistic fee levels for the lead consultant on this project allowed the necessary level of testing and design fine-tuning during the concept and design development phases.

Adequate cost planning.
The cost planning and cost budgeting process was undertaken rigorously by the Client’s Quantity Surveyor in order to maintain a strong relationship between design and cost-effectiveness.

Co-location.
Close proximity of all members of the consultant team, housed on one floor of a building opposite the site supported effective communications.

5.1.5 Optus Playhouse, Stage 5 Queensland Cultural Centre, Brisbane
In a considered effort to maintain the design integrity and aesthetic of the existing Cultural Centre complex the Principal engaged the original architect for Stages 1 – 4 to design and document Stage 5. The procurement method for the Optus Playhouse was by a traditional lump sum contract, whereby the documentation was completed prior to tender for construction being called.

However, there was a significant time lag between the formulation of the brief, the design and documentation, and the construction of the building. Though requirements were fully identified at the planning stage, and documented as approved, a significant variation relating to changed client needs was introduced to the project at a late stage during construction. Changing arts funding policies necessitated more extensive food and beverage facilities to be incorporated into the new building.

The project was complex both in terms of design requirements and in terms of the relationships between the multiple stakeholders. Though the proponents were required to operate within the adversarial framework of a traditional lump sum contract, they sought to work cooperatively.

Perceived inadequacies in the documentation was the source of some difficulties during the construction phase. Documentation was undertaken in the early 1990’s when the use of CAD on large projects was still evolving. Consultants were utilising CAD to varying degree and some frustrations were experienced with co-ordination of sub-consultants’ work.
5.1.6  Browns Plains Interchange, Logan City
The project was procured by a traditional Schedule of Rates contract and was completed in December 1999, eight months ahead of schedule, by Bielby Holdings, a Queensland-based construction company.

Success Factors:
- Previous experience.
Bielby Holding’s core business is the delivery of infrastructure projects for the public sector. The skills and experience of specific personnel involved, notably on the part of Main Roads’ Resident Engineer and Bielby’s Project Manager were important to the success of the project’s construction phase.

- Quality of working relationships.
Trust and respect existed between client and contractor. The client’s Resident Engineer responded to the contractor’s problem-solving culture by being willing to listen and making informed decisions.

- Financial reward
Incentive for early completion benefited both the contractor and the client.

The concept of partnering was also embraced by those involved in this project. This served to foster a non-adversarial environment. However, the knowledge and skill of those involved in the project leadership and their collaborative approach produced significant results in terms of project success.

5.1.7  Neville Bonner Building at 75 William Street, Brisbane
The site for a new State Government office building coupled harsh environmental conditions with unique urban planning constraints including a long visual exposure to the Brisbane River on the western side. The client conducted a selected design competition for schematic design to resolve the complexities of planning. The successful architectural team was subsequently novated to the Managing Contractor as were the client’s sub-consultants.

This project was also subject to some delays between the original design competition and subsequent phases. The main issues extracted from this case were:
- Key personnel.
The client’s representative played a pivotal role in project success. This person’s experience was a positive influence in a project team, which was characterised by differences of organisational culture.

- Team cohesion and job satisfaction of the participants was adversely affected by tight profit margins and unrealistic deadlines. Further, the procurement system adopted for this project did not successfully overcome the “them and us” attitude that often prevails between contractors and designers.
5.1.8 The Woodford Correctional Centre
The Queensland Corrective Services Commission Board (QCSC) called tenders for the design, construction and operation of a 400-person facility for male prisoners at Woodford in early 1995. Two private sector tenderers and one public/private consortium were invited to prepare bids. The successful tenderer was the private/public consortium comprising the QCSC as operator, Concrete Constructions Pty Ltd as the builder, Project Services (a commercial section of the Qld Dept PW&H) as specialist adviser and superintendent. Phillips, Smith Conwell were the architects. (Heldt, Hampson, Murphy, Wood, Deck and Tucker, 1997)

The pivotal issue in this case study was that the design of the Woodford Correctional Centre integrated technical requirements and operational philosophy such that design, construction and operational methodologies were inseparable in terms of the tender process. Heldt et al (1997) suggest that the early input from the client, construction company and facility operator combined to drive the operating costs of this prison to substantially lower levels than previously achieved in Australia.

Another key issue in the development of this project was the re-negotiating of employment agreements with QCSC staff whereby a new industrial award, based on this facility’s greenfield site status was struck to allow a series of amendments to existing work practices.

Heldt, et al (1997) say that the project was procured by a purpose-drafted Document and Construction contract that incorporated an “in good faith” clause which bound the parties to “act in a manner which is fair, reasonable and honest”, and confirmed the parties’ agreement to specified common goals and their commitment using partnering principles in administering the contract.

Heldt et al (1997) identify the three key advantages of the contract negotiation process used throughout this project:

- The owner was able to maintain control over the design process. An acceptable concept design was obtained prior to formalising the assignment of documentation and construction risk to the builder.

- The builder clearly understood the scope and nature of the necessary building works prior to agreeing to a Contract Sum, and

- The owner benefited from the design management and value engineering skills of the builder during the design and construction phase.

5.1.9 Pacific Motorway, Package 2, Yatala to Pimpama, South East Queensland.
The complex and technically demanding retrofit of a major highway to an existing corridor, under heavy traffic, was essentially a construct only contract. The Schedule of Rates Contract and AS2124 was adopted in order to allow Main Roads to maintain control over design standards for the full 43km length of highway, with implications for future maintenance and operation.

The project was characterised by a foreshortened time frame, which impacted on
planning, design, and documentation aspects and so on.

Due to escalating project delays and difficulties, an adversarial relationship flourished between contractor and principal, which contributed to a low level of trust. Problems on site were exacerbated by delays in the relocation of public utilities, prolonged wet weather, and delays due to RFI’s.

As deteriorating relationships persisted, the Queensland Dept of Main Roads responded by installing a Relationship Management Unit. The Unit worked successfully to re-establish commitment to mutual project goals and rebuild relationships. The parties achieved success in time and quality outcomes.

5.1.10 The National Museum of Australia, Acton Peninsula, Canberra
The flagship building for Australia’s Centenary of Federation celebrations was successfully delivered using a fully integrated project alliance. According to Peter Wright, project manager for Bovis Lend Lease, the main contributors to project success were:

- Positive participation of all alliance members.
- Constant pursuit of innovation by the team – all ideas were considered.
- Ability to change quickly if necessary.
- Information control, exchange, storage and retrieval maintained on an internet platform. IT was highly advantageous in the management of supply chain issues.

The foregoing factors were made possible by the client’s commitment to the project. Willingness to embrace the concept of equitable risk allocation was a clear indicator of the client’s commitment. Such commitment consequently paved the way for a highly evolved and co-operative project team.

The exploitation of Information Technology to achieve alliance objectives was particularly successful in this project and highlights the potential of Information Technology as a driver and catalyst for a truly re-engineered construction delivery process.

5.2 Critical issues
The data gathered in preparation of each of these case studies highlighted characteristics common to successful projects as well as issues common in the construction industry.

5.2.1 Equitable Risk Sharing
In most of the cases researched, the concept of outcome-based reward is applied only to the Principal and the Main Contractor, and is based on the main deliverables of cost, time and quality. If the form of contract allowed a mechanism for the consultant team to share incentives (or penalties) based on those same deliverables, an outcome that further improves benefits to the client and end users may result. The entire project team would be involved in a high risk/high gain enterprise.
The Acton Peninsula project demonstrated the fundamental concept of embracing risk within a co-operative working relationship. Equitable risk sharing will be an essential element of the procurement culture.

The Pacific Motorway Package Two case study highlighted the pitfalls of risk allocation on a project with complexities such as those presented by such a major infrastructure project. The project risks were well defined and only pre-qualified contractors with the capacity to absorb the impact were invited to tender. However, given that the Department of Main Roads contracting environment will continue to increase in complexity and stakeholders will be more numerous and sophisticated, the outdated philosophy of transferring risk is likely to be replaced by more flexible arrangements.

5.2.2 Co-operative project teams
Fragmentation of the project team has traditionally characterised the construction industry. Rather than the members of project teams being aligned toward project goals, the adversarial attitudes toward other parties, which exist in industry personnel through training and on-the-job experiences, are reinforced.

However, during the course of this investigation many proponents of the industry suggested that conflict and disputes are no longer a valid part of the construction industry landscape. The focus tends to be more and more on the right people for the job, regardless of the procurement process. The variety of projects procured by a variety of methods included in our study seems to confirm this observation. However the evidence is anecdotal only and was not rigorously tested apart from the work done by Hampson, Peters, Walker and others in the Case Study of the National Museum of Australia (2001). It is evident that the groundwork for a co-operative project environment is laid at project inception by the approach and attitude adopted by the owner.

In temporary project organisations, particularly in novated situations, where consultants and contractors are “thrown together” it is essential to establish good working relationships reasonably quickly because getting required information in a timely manner is crucial for prompt decision making and project success. Project participants are more willing to share important information if they can work together and trust each other (Chan et al, 2001).

Contractors interviewed acknowledged that as well as expertise in terms of construction, and construction techniques, personnel need relationship and communication skills in order to deliver results both for themselves and their customers.

The case of the Woodford Correctional Centre illustrated the benefits, which can be accrued through innovative procurement approaches, which demand communication between all project stakeholders. As trust developed between the stakeholders, the “good faith” clause was viewed as less threatening, and the emphasis shifted to “dispute resolution” and “value for money”. Such co-operation industry-wide requires a paradigm shift by the industry as a whole from an adversarial approach, to
one of co-operation and mutual respect. Co-operation instead of conflict can result in lower risk for all stakeholders.

In both the successful D & C cases researched for this report, the main contractor did not shop around for consultants but selected their project team members based on reputation. This attitude of trust and respect assists in smooth running within the delivery team.

5.2.3 Consultants’ fee levels and quality of documentation
This joint issue has potential to affect the level of teamwork and co-operation experienced at project level. In at least two of the cases studied, the contractor expressed dissatisfaction with the standard of documentation supplied. In at least three cases, consultants expressed dissatisfaction with fee levels and expectations placed upon them in the face of tight profit margins and unrealistic deadlines.

In a recent study on design and documentation quality, and its impact on the construction process (Tilley, McFallan and Tucker, 2000) it was found that reduced fee levels paid by government and industry clients to consultants is one of the direct reasons that sub-standard documentation occurs. Tilley et al (2000) found that reduced fee levels have detrimentally affected documentation completeness, certainty, co-ordination and final checking. As a result, clients/contractors get what they pay for! Two of the case studies confirmed that inadequate documentation prepared by consultants translates into delays and cost increases in the construction phase.

The impact of inadequate fees on a project can be substantial and must point to a false economy in a project procurement system which seeks to make a one percent saving on consultants’ fees in the early phases of a project. This is demonstrably not cost-effective and can lead to significant overall project cost increases.

Conversely, if money is spent wisely in the design phase, value-adding occurs in the construction and subsequent operation and maintenance stage. Value for money can be achieved where fee levels are adequate to allow an appropriate degree of testing of options in the concept and design development stage to achieve overall cost-effectiveness.

In a tight market, consultants have been obliged to bid on price alone in a highly competitive market. Various factors combine to force them to under-bid fees in an effort to win the job.

Novated consultants’ reduced levels of satisfaction may also be attributable to the expectation on the part of their client (the main contractor) that they bear the cost of documenting amendments and variations without recourse to negotiation or cost recovery which result.

In contrast, consultants involved in the Acton Peninsula Alliance estimated their base costs and these were covered directly by the Alliance. Alliance members’ profit was put up to risk based on the capacity of each party. Design costs on that project
increased substantially, however the attitude taken by the Alliance was that more intellectual input led to a better result. The emphasis was placed on “getting it right” and the recognition that input from specialist parties would enhance the outcome for all. Increases were subject to negotiation and unanimous agreement by all members of the alliance.

5.2.4 Whole-of-life process issues
In its exaggerated time frame, the Optus Playhouse case study has drawn attention to the fact that investigation of the process needs to include the phases prior to and following the design and construction phase to truly make a difference in the way construction projects are procured. A truly re-engineered process would include the earliest phase of commitment and project definition and not stop at Practical Completion but the implications of operation and maintenance would be taken into account as well.

A way of overcoming the potential problems of spiralling long-term operating and maintenance costs on projects would be to tie on-going asset management or operating costs to rewards. In this scenario, the contractor would be responsible for the maintenance of the facility over a set period of operation.

5.2.5 Supply chain issues
Supply chain relationships are often the key to achieving the traditional performance indicators of time, cost and quality. The research on the Norman River Bridge case study pointed to the selection and engagement of major sub-contractors as a weak point in the delivery process. A sub-contractor whose role was pivotal to the timely project delivery was not part of the alliance and thus was not compelled to adopt the “spirit of the alliance”.

Sub-alliances with various service providers replaced traditional sub-contracts on the Acton Peninsula Project. Benefits gained for the project through sub alliances were:
- Parties were able to contribute to buildability and cost issues early
- Parties were proactive in their roles
- Parties gained a higher level of satisfaction by being involved from the outset of the project
- There was greater opportunity for knowledge transfer and innovation. (Peters 2001)

Participants in the Acton Peninsula Alliance felt that the project would have benefited even more had key consultants been included in the alliance as well.

However, given that the accepted process for spending public funds involves open competitive tendering against prescriptive conditions it may prove difficult for the industry and the public sector to embrace alliancing as it may pertain to sub-contractors.

5.2.6 Agreed project outcomes
The very simple but effective difference between the delivery method adopted for the construction of the Museum of Tropical Queensland and other Design and Construct
contracts is the fact that the cost was set, and declared by the client, prior to expressions of interest being called. Subsequently, tenderers were competing on non-price criteria to complete the project. The implication was that the winning tender would represent the best value for money for the client.

Many Design and Construct contracts are cost-driven and the tender sum is usually based on a concept design drawn at small scale where every item is not detailed and it is not possible to accurately cost all items. (APP, 1998) This lack of certainty has traditionally confounded Design and Construct contracts as it presents scope for contractors to take opportunities to exploit the process. Under this situation the client’s interests may not be adequately safeguarded. This scenario cannot occur when a detailed briefing document is supplied by the client and the contractor provides a “return” brief confirming scope, as was the case in the Museum of Tropical Queensland project.

The smooth running of Design and Construct type contracts may also be adversely affected by a lack of understanding of roles and responsibilities on the part of the client. Some clients erroneously believe that a Design and Construct allows them to alter the scope of work, or the design, without incurring additional costs or without administering a cross-savings system. If the process is not managed to control variations, the process breaks down, opening the way for conflict and dissatisfaction between the parties.

In each of the D&C cases researched this scenario did not occur because both the client and the contractor were well aware that the contract was a commercial system in which the contractor was acting in a contractual capacity with a commercial interest in the project.

Through seeking an alternative to the traditional lump sum method, the client in both cases was able to access the expertise of the best proponents in the industry. As a result, the procurement method produced buildings with added-value attributes, which exceeded their client’s initial expectations.

The managing contractor form of delivery as used in three of the case studies is an attempt to overcome some of the difficulties perceived to exist with D&C contracts. In most aspects this project delivery system worked well, though savings sharing clauses which weight cost performance at the expense of other areas of performance such as quality, and design integrity may have lead to some compromises.

5.2.7 Costs of tendering

The cost expended on bid activities is an issue, which causes on-going concern to the construction industry. In most cases, minimum submission requirements and a corresponding fee were supplied to short listed tenderers. Determining the correct level of submission requirements can pose a dilemma for clients. If these requirements, or fees are too skimpy, the result may be insufficient information for the selection panel to determine a “winner”. If they are too high, it may be difficult to justify the cost to the industry.
In the case of the Museum of Tropical Queensland, the client organisation stipulated minimum submission criteria. Most consortia went beyond these requirements in their submissions. The five short listed groups collectively spent well in excess of the minimum requirements specified by the Queensland Museum Board.

The tendering process adopted by BACL for their multi-deck long term car park was costly to the many potential contractors and consultants who registered expressions of interest and who were subsequently shortlisted. Five D&C tenderers were required to prepare not one but two complete bids because of the client’s notification that non-conforming bids would be accepted provided that a conforming bid was also submitted.

5.2.8 Innovative use of Information Technology

Rather than “re-paving the cow path” by using new technology for established processes, the use of evolving IT is bringing with it new ways of doing things in the construction industry. In this scenario, 2D drawings may soon become obsolete.

Steve Ashton, Project Director for the architectural joint venture for the Acton Peninsula project believes that IT used innovatively has the potential to become the ultimate “design and construct” mechanism (Ashton, 2000). It is possible to provide a full description of the internal and external surfaces as the design intent document, with total constructability flexibility in the spaces between. It is becoming increasingly possible to fully co-ordinate all services and structure in a current and updateable three-dimensional electronic model. Clients will be able to sign-off the design on the basis of the 3D model. This was demonstrated successfully on the Acton Peninsula project. The model was maintained throughout the preparation of contract documentation and construction. Re-drawing was eliminated and the need for shop drawings obviated in most cases.

Current drawbacks with the use of a fully integrated virtual project team are the capacity and reliability of the various parties, including consultants and fabricators to support the hardware and software required.

5.3 Conclusion

This investigation involved a small sample of the diversity of projects which the construction industry is involved in. However, analysis of the characteristics of these projects may assist construction industry proponents to gain some insight on how to achieve superior results on projects. The results of the case study analysis tallies closely with the statistical analysis presented in Section 4. Desirable conditions such as co-operative project teams and equitable risk allocation can only be achieved through strong owner commitment and leadership.

Each of the issues identified through analysis of the case studies are intrinsically bound to leadership and client commitment. Competent clients are those who seek appropriate advice on approaches to project procurement if they do not already possess the experience and expertise in house.
The people/communication factor is integral to success of re-engineered procurement and workflow processes. A major shift from entrenched processes and behaviours to a new process requires strong commitment from, and mutual trust between, senior manager’s client, consultant, contractor and user organisations.

Interorganisational teamwork among all project participants may require specific attention to be paid to team relationship building.

The use of evolving IT techniques signals the way for truly collaborative project procurement, requiring deeply committed client and project teams and whole-of-life approach to the design and construction of projects.
SECTION 6 Industry Think Tank

6.0 Think Tank Participation
The think tank took the form of an intensive half-day focus group, using the nominal group technique. It was facilitated by Professor Vernon Ireland, currently CEO of Australian Graduate School of Engineering Innovation (AGSEI).

The think tank gathered together a combination of twenty-six participants from various sections of the construction industry with a combination of qualities including the ability to think laterally, extensive relevant experience, and enthusiasm about the subject. Participants included people from client organisations, contractor organisations and consultant organisations with expertise in both buildings and infrastructure projects.

6.1 Issues raised by the focus group
The discussion identified significant points regarding procurement processes:

➢ The process of procuring a project begins at inception and does not end at project completion. Life-cycle considerations cannot be ignored at any stage of the process.

➢ Project leadership needs to recognize the complicated set of issues impacting on a project and address them by capturing relevant expertise and bringing it into the process as early as possible.

➢ As a result of a proliferation of organizations involved in the construction delivery process, duplication of effort within the process is experienced, but at the same time and just as frustrating, is an inadequacy of documentation.

➢ One size does not fit all – issues and solutions for building projects may not be suitable for engineering infrastructure projects and vice versa.

➢ Artificial time frames dictated by political, environmental, or business needs may not advantage the project to the optimum outcome.

➢ Probity issues can sometimes be used as an excuse not to enter into a new process. Better to advocate the familiar method of delivery rather than risk a new way of doing things.

➢ A value-driven tendering process advocated over a purely price-driven process.

➢ Rational project management procedures must be underpinned by non-rational factors like trust, trustworthiness, co-operation and commitment to project goals and objectives.

➢ Delivery systems need to catch up with industry capability.
6.2 Output
The think tank established that regardless of size or scale, a construction project consistently follows an iterative process which takes it through five basic phases which vary in intensity or importance depending upon the project: Idea, Planning and Design, Construction (Implementation), Commissioning, and Operation.

Through a process of clarifying priorities, the think tank established six best practice objectives to achieve successful project procurement:

1. Value to parties – how to achieve value for all the project participants/stakeholders.

2. Alignment of objectives – break cycle of mistrust currently driving the industry.

3. Holistic process – whole of life approach to project outcome, including a longer-term approach to shareholder value if applicable.

4. Value-driven selection process for all service providers.

5. Eliminate duplication of effort – no ambiguity or confusion about roles or responsibilities.

6. Process not contractual arrangement – look at how to achieve high standards in key performance measures through fundamental process rather than through various existing contractual arrangements.

These key objectives and the virtual phases were combined into a matrix as a way of conceptualising a process, which would result in enhanced outcomes to parties.

<table>
<thead>
<tr>
<th>Objective/Phase</th>
<th>Value to parties</th>
<th>Alignment of objectives</th>
<th>Holistic process</th>
<th>Value-driven selection process</th>
<th>Duplication of effort eliminated</th>
<th>Process not contractual arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea – identifying a need</td>
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<tr>
<td>Planning &amp; design</td>
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<tr>
<td>Construction</td>
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<tr>
<td>Commissioning</td>
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<td></td>
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<tr>
<td>Operation &amp; maintenance</td>
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</table>

Table 6: The decision matrix resulting from industry think tank.

At the culmination of the workshop, participants were asked to consider how these objectives could be achieved through the generic project phases, using a “decision matrix” as a tool. Responses would be gathered in an on-going process of consultation.
6.3 Round 2 survey results

Table 7 incorporates the results of Round 2. Phases are not discrete but may be combined or are iterative. The “matrix” may be seen a decision support tool. The objectives are not a step-by-step list of instructions.

- Achievement of objectives in the early stages of a project could improve this phase for clients, allowing them to make decisions on construction, or alternative project solutions, from an informed knowledge base rather than from inexperienced ignorance. (Kagioglou M, Cooper R, & Aouad G, 1999)

- Consultative fee based arrangements for pre-project consultation is important to protect industry participants against the loss of ideas, and work. (Kagioglou et al 1991). Pre-project consultation should not be regarded as speculative work. Speculation devalues the input for both client and service provider paving the way for mediocrity rather than excellence.

- The people/communication factor is integral to success of re-engineered procurement and workflow processes. A major shift from entrenched processes and behaviours to a new process requires strong commitment from, and mutual trust between, senior management of the client, consultant, contractor and user organisations.

- Effective management of fundamental change from accepted procurement practices requires a leader/process-owner who can cross the barriers between the separate project participants. (McGeorge, 1997)

- Application of re-engineering objectives should result in smoother site operations, fewer construction delays, time and cost savings. (Ireland 1994)
<table>
<thead>
<tr>
<th>PHASE</th>
<th>Value to parties</th>
<th>Alignment of objectives</th>
<th>Holistic process – lifecycle</th>
<th>Value-driven selection process</th>
<th>Duplication of Effort</th>
<th>Process not contractual arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IDEA</strong></td>
<td>Resolve customer needs and business objectives by determining 'what the business needs to be'</td>
<td>Develop indicators of success. Satisfy the individual business needs of each participant. Seek high degree of stakeholder alignment.</td>
<td>‘Front end’ participation by a wide spectrum of expertise to predict, and inform, whole of life issues including shareholder value. Document results for decision-making in later phases.</td>
<td>Client to ensure personnel involved in selection of service providers are skilled to an appropriately high level and are independent. Match project risk profile to service provider capability. Value for money, not price.</td>
<td>Assemble the virtual design and construction team by matching expertise to objectives. Establish appropriate team structure.</td>
<td>‘Front end’ participation by a wide spectrum of expertise to predict, inform, and design out problems which might be encountered at the later stages of the project process. Front-end participation by aligned customer stakeholders.</td>
</tr>
<tr>
<td><strong>PLANNING and DESIGN</strong></td>
<td>Participation of stakeholders including customer stakeholders in planning and design process. Minimise late stage design changes. Team-building concepts, which avoid conflict and assist convergence of interests, add value by increasing productivity. Agree on documentation requirements.</td>
<td>Enhance working relationships between parties through team-building concepts. Co-ordinated resolution by all parties. Constructor input in design phase. Closer collaboration on development of delivery method to meet procurement objectives. Better alignment of commercial interests. All participants share savings – genuine incentive alignment.</td>
<td>Value engineer the entire process including operations. Consider impact on other parts of the virtual organization when making decisions. Prototype new ideas and record that takes risk &amp; reward. Identify non-conformities. Can be rectified now for fraction of downstream cost. Open communication</td>
<td>Consider impact on other parts of the process when making decisions on downstream contractors/suppliers/operators. To be selected using similar non-price criteria as for other providers.</td>
<td>Eliminate ambiguity and confusion about roles and responsibilities. Establish effective open communicatioon between the parties. Eliminate non-value adding activities.</td>
<td>Ensure co-ordination role lies with appropriate party. Integrated supply chain. Investigate new approaches to improve construction output – “learning” project teams.</td>
</tr>
</tbody>
</table>

Re-engineering the construction delivery process
### Table 7: Final decision matrix.

The response generated by the Think Tank has not yet revealed a radical process improvement – as opposed to the incremental process improvement, which the industry is constantly striving for. However, this principles-based decision matrix may make re-engineering the process possible by providing a tool to identify better ways to achieve optimum value for all stakeholders than using existing delivery methods would.

The work done here has provided a springboard to a wider construction industry project within the Co-operative Research Centre for Construction Innovation. Further research will be carried out under the title ‘Value Alignment Process for Project Delivery’.

The Think Tank exercise reconfirms that the will to change exists in the construction industry. Three areas for change and improvement have been identified as process, organisational arrangements and changed focus on what ‘success’ means. In some ways it seems that the responsibility for change lies with the client organizations and

<table>
<thead>
<tr>
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<th>Process not contractual arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPERATION</td>
<td>Benchmark operations</td>
<td>Feedback to all parties regarding actual operational performance. Possible bonuses for exceptional performance.</td>
<td>Analyse and evaluate operations costs as part of the WOL costs – not as a separate entity.</td>
<td>Success or failure of a project to be measured in terms of operational success performance.</td>
<td>Commissioning strategy to be closely aligned to actual operating philosophy.</td>
</tr>
</tbody>
</table>

**Table 7 : Final decision matrix.**
their advisers. This may be true of client organisations such as Main Roads or Public Works, Queensland Government departments whose core business is to procure major capital projects. However, most clients do not have in-house expertise for the development of building projects and rely on experts within the construction industry itself to guide their decisions.

Therefore, it is the construction industry as a whole, which needs to re-think the process of procurement and work to re-shape attitudes and approaches in order to achieve the win/win outcomes it, seeks. The industry needs to educate clients to become ‘informed buyers’ who can take their place within a collaborative project team, where the players work together to achieve the desired outcome for all involved.
SECTION 7 Conclusion

The increasing complexity and sophistication of the construction industry has outstripped the ability of the logical but simplistic traditional procurement process to deliver major projects effectively. Industry reports and commissions of enquiry over the past sixty years have identified a multitude of problems and potential solutions. The industry has developed new procedures but these have tended to be piecemeal and reactive rather than proactive. We have been unable to find a “magic bullet” that will address all of the challenges in delivering projects.

However, recent investigations such as the Latham and the Egan Reports in the UK and in Australia, Construction Queensland’s report on Equitable Asset Delivery, the evaluation of success of the Acton Peninsula strategic Alliance, and the work by Ireland and others looking at application of business process re-engineering have identified some significant contemporary issues, these are:

- Equitable risk/reward relationships between the parties.
- Responsible participation by the client.
- Pre-qualification and capacity of all team members
- The creation of an integrated team by use of alliancing or relationship building.
- Agreed benchmarks and key performance indicators for quality and performance.
- A focus on value rather than cost.

This research project was led by an industry task force under the aegis of the Construction Industry Institute, Australia. The researchers developed a model and survey instrument following evaluation of previous work and the practical contemporary expertise of the team.

Ten case studies elicited fifteen project-related factors, which were critical to project success. These were:

- Co-operative project team
- Client’s competency and commitment
- Continuity of key personnel on the project team
- Well-defined functional brief
- Complexity
- Regular monitoring of key objectives
- Effective communication process
- Availability of suitable contractors
- Consultant selection criteria
• Mechanism for reward and penalty
• Clear reporting lines
• Client’s preparedness to absorb risk
• Shared responsibility to project problems
• Equitable risk allocation
• Selection of subcontractor

Stepwise multiple regression analysis\(^4\) identified four factors, which explained 64.9% of the overall performance variance. These results are consistent with the findings by other researchers. The four most important determinants of project success were found to be.

1. Co-operative project team. Elements such as commitment, trust, non-adversarial relationships and characteristics of teamwork engendered by approaches such as partnering and alliance contracting all contribute to a co-operative project team.

2. Clients’ competency and commitment. The Latham and Egan reports in the UK and the BCA report in Australia have emphasised the importance of client involvement in the project team. Such involvement, particularly from experienced clients serves to minimise miscommunications on issues such as the brief, quality, time and cost priorities etc. The client is able to facilitate decision-making, interpretation, strategic and tactical objectives.

3. Continuity of key personnel on the project team. This factor highlights the importance of developing and maintaining good working relationships. Also significant is the maintenance of the project “corporate memory” so that data are not lost and key decisions forgotten.

4. Equitable allocation of risk. Effective risk identification, analysis and management techniques together with equitable distribution to those parties best able to cope with the risk are now well-accepted as key determinants of successful projects.

The research team tested these findings against a group of industry experts in a facilitated workshop. The outcome of the workshop was a decision matrix focussed on six principal variables that are relevant in today’s procurement industry to the determination and achievement of a project delivery process centred on maximising value to all the parties. These variables are:

1. Value to parties – how to achieve value for all the project participants/stakeholders.

2. Alignment of objectives – break cycle of mistrust currently driving the industry.

\(^4\) The statistical analysis of the relatively small sample size of 40 data sets for ten cases can only be judged as indicative.
3. Holistic process – whole of life approach to project outcome, including a longer-term approach to shareholder value if applicable.

4. Value-driven selection process for all service providers.

5. Eliminate duplication of effort – no ambiguity or confusion about roles or responsibilities.

6. Process not contractual arrangement – look at how to achieve high standards in key performance measures through fundamental process rather than through various existing contractual arrangements.
**Postscript**

The development of the decision matrix marks the completion of the CIIA and ARC funded SPIRT project titled “The development of a re-engineered construction project delivery process”.

In 2001, the Federal Government approved the CRC for Construction Innovation with twenty industry, government and academic parties, based at QUT in Brisbane. The CRC has five research programs:

1. Virtual Environments for Lifecycle Design and Construction
2. Construction Project Delivery Strategies
3. Environmental Sustainability
4. Integrated Design and Construction Support Systems
5. Management, Adaptability and Future of Built Assets

Program 2, Project delivery strategies, commenced with two projects:

2A Value alignment process for project delivery
2B Delivery Knowledge Management and Innovation Diffusion.

The research team for project 2A has adopted the results of the re-engineering study as the starting point for its research. The decision support matrix will be used as the basis for the first research best practice case studies. Further information is available from [www.construction_innovation.org](http://www.construction_innovation.org).
References and appendices


Kennedy, R.J. (2001) Re-engineering the Construction Delivery Process, Think Tank Report for the CIIA.


