INNOVATION AND EVALUATION IN PROCESS IMPROVEMENT

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Perceived problems of inefficiency in the building process have resulted in development of a range of innovative procurement strategies to overcome problems. Many of the individual strategies have attempted to solve at least one of the inefficiencies in the process, with some more successful than others. An apparently innovative procurement system was examined in an effort to understand the difficulties in re-engineering the procurement process. The project highlighted several problems in trying to be innovative in the design development phase of a project, in particular whether the desired features can be identified and assessed before implementing a new procurement system.

The aim of a methodology for assessing a procurement system is to provide a procedure to evaluate the appropriateness of a particular procurement system (or systems) for a specific project and the objectives of the client. A range of factors has been identified as describing the requirements of a procurement system and thus influencing the decision on which procurement system to use. A re-engineered procurement process must be measured against the existing systems and must rate more highly if it is to qualify as an improvement. The approach described here incorporates a number of factors through an interaction matrix, which determines their relative contributions to the success of a project. This interaction matrix is used to combine the strengths of the factors into a single value by which the possible procurement systems can be ranked taking into the account the client objectives and the characteristics of the project.

Keywords: Construction re-engineering, procurement, project delivery methods.

INTRODUCTION

Numerous inquiries into the efficiency of the building process, (e.g. Banwell 1964, Gyles 1992, Latham 1994) conclude that the characteristics of the engineering and construction industry which inhibit its effectiveness are organisational fragmentation, lack of co-ordination and communication between the key parties, adversarial contractual relationships, inferior working conditions, industrial relations and lack of customer focus. Yet the traditional process has some signal characteristics which continue to hold relevance in today's climate for construction.

In recent decades the industry has developed a range of procurement strategies to overcome the perceived inefficiencies in the traditional process. For example, management contracting was a hybrid of construction management (first developed by Arup Associates for the John Player factory in the UK in 1968) and took advantage of the contractor's management ability while retaining competitive bidding for subcontractors. 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

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controlled design and construct. Partnering is an attempt to minimise adversarial relationships, mostly by developing trust and establishing agreed alternative dispute resolution techniques (e.g. Lenard *et al.* (1996) identified the variables that lead to successful relationships in project teams). Each of these strategies tackles at least one of the inefficiencies in the procurement process, but none takes an holistic approach, with the result that the overall effectiveness of each is not assessed.

Two recent Australian studies in re-engineering construction (Ireland 1994 and Mohamed and Yates 1995) identified solutions which could reduce non value-added steps in the process. Ireland (1994) suggested a six part solution - Agreed common goals between customer and delivery team, Simplified process, Re-engineered activities, Workforce commitment, Partnering with local government, and Tendering on the basis of benchmarked performance; while Mohamed and Yates (1995) concluded that successful application of the concepts were highly dependent on six key factors - Strong commitment by the team, Effective communications, Positive customer involvement, Quality assurance techniques, Encouragement of innovation, and Improved construction output.

These studies, which demanded improvement in the construction industry, caused industry practitioners, and researchers to promote re-engineering (stemming from Hammer 1990) as a concept which could be implemented to improve the performance and productivity of the construction industry (e.g. Betts and Wood-Harper 1994, Mohamed and Tucker 1996). In practice, however, there is a mind-set which prefers the familiar traditional procurement system (e.g. Root and Hancock 1996 and Hashim 1997). Again, there was no attempt to measure how successful these strategies could be in comparison to existing approaches.

A case study of a project which was believed to be innovative (the substantial upgrade of an oil refinery wharf) was investigated in association with the Construction Industry Institute, Australia (CIIA) to examine the use of innovative procurement methods. The wharf project highlighted several problems in trying to be innovative in the design development phase of a project, in particular whether the desired features can be identified and assessed before implementing a new procurement system. This led to development of a method of assessment of a proposed procurement system to provide a procedure to evaluate the appropriateness of a particular procurement system (or systems) for a specific project and the objectives of the client.

THE DESIGN DEVELOPMENT PROCESS

The owners of the wharf wanted to apply many of the ideas for improving the process, to develop a close relationship with the team, to use partnering, and to take full advantage of constructability by involving the constructor. The project went through eighteen stages in the process of developing the brief, appointing consultants and obtaining bids from contractors. The design development process adopted by the wharf owners is outlined in Figure 1.

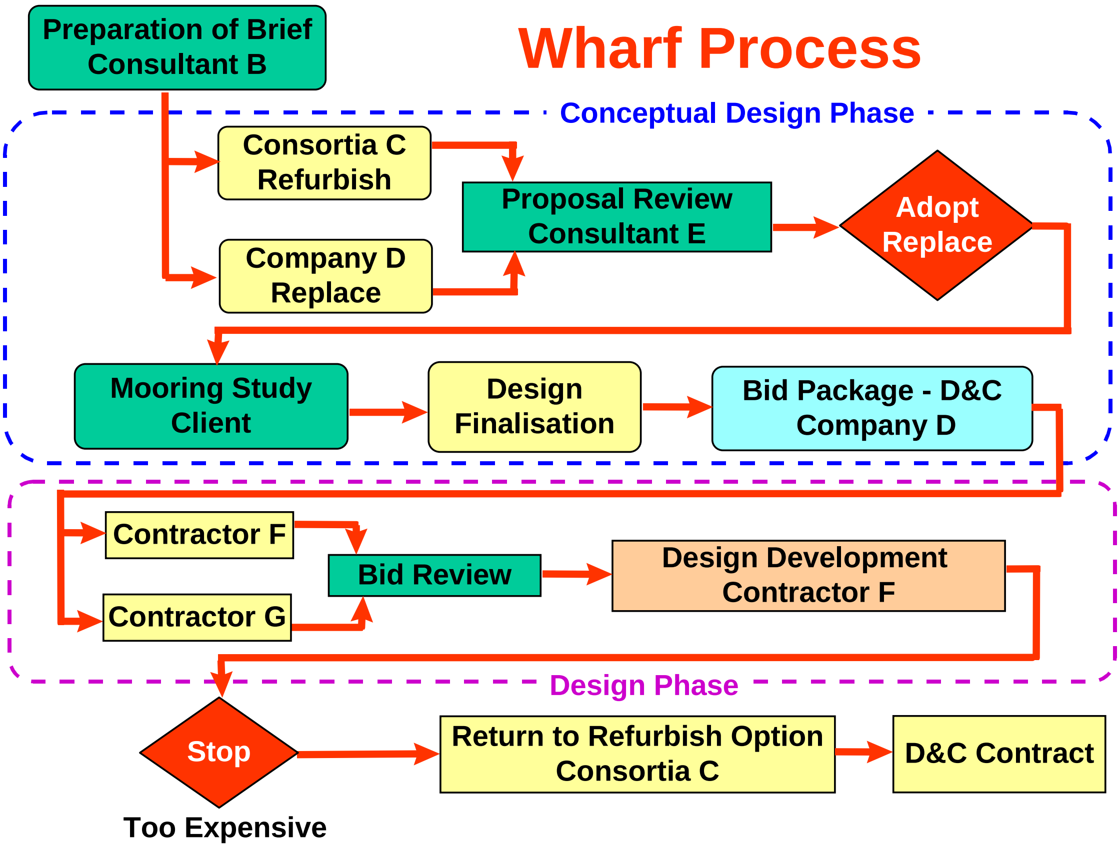

Figure 1: Wharf design development process

The wharf serves an oil refinery in Australia with lube refining capacity and is used for the delivery of refined products to ships as well as supporting the crude oil pipeline, which runs from a separate mooring buoy located offshore. The need for upgrading the wharf results from an assessment of the increasing maintenance costs involved in the upkeep of the 30 year old wharf, to prevent damage that could cause considerable delay in refinery operations.

The process adopted had a number of innovative approaches such as the separate consultants who were paid to undertake preliminary design work and budget estimates. The consultants were actively involved in the conceptual design including scope definition and these were incorporated into each of their final proposals.

The replacement option was adopted and the winning consultant developed a comprehensive bid package, which included detailed design development drawings. This was passed on to two preferred tenders who estimated the cost and outlined their construction process. Upon receiving the commission, the successful tender instigated an intensive three-day workshop to lock down the scope of work. Design development was an intensive two-month period when all consultants and the client were brought together and culminated in a two-day value-engineering workshop.

The 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 project still failed in its ultimate aim. It was towards the end of this process that a substantial overrun in budget was considered highly likely and, therefore, the client decided to halt the project and return to the refurbishment option, which has since been adopted with a traditional design/head contractor arrangement.

Several key areas, which need to be investigated further to establish their role in contributing to the unexpected late change in options, have been identified:

- 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
- Expectations of client and consultants - understanding and management of outcome
- Cost consequences of key changes
- Decision/approval check points
- Impact of initial contractor estimate possibly being too low

The case study illustrated a trial of some issues; for example, the client and the team went to great lengths to ensure that there were agreed common goals, strong commitment by the team, effective communications and positive involvement by the customer. The design development process certainly resulted in clarifying the technical issues in the project and this enabled the client to make a reasoned, accurately costed, decision on the viability of the project. In these respects the process was a success; one could speculate that a less thorough process could have locked the client into a contract which was subject to escalating cost and time.

The case study showed a large degree of innovation in an attempt to achieve the best possible outcome, but, more importantly, it showed that innovative processes often solve one difficulty or ensure that a particular requirement is met yet fail to guarantee that other characteristics are retained. Thus, it was concluded that some method of assessment of a proposed procurement system was essential to identify an overall best choice (taking into account strengths and weaknesses).

FACTORS AFFECTING CHOICE OF PROCUREMENT SYSTEM

Hashim (1997) investigated the client's criteria on the choice of procurement systems and identified 14 criteria which were ranked separately by clients of traditional, design and build and managing contracting systems. He pointed out that the *client ought to make clear … what the objectives of the project are* and by inference what the client's objectives are. The study concluded that *procurement method is not a good predictor of performance. Other variables that will affect performance will be the building designer's experience, the contractor's capabilities, the client's characteristics and also the project characteristic*s. No method of assessing the impacts of these variables was discussed.

With such requirements in mind, the aim of a methodology for selecting a procurement system should be to provide a procedure to evaluate the appropriateness of a particular procurement system (or systems) for a specific project and the objectives of the client. Measuring the appropriateness of a procurement system is the most difficult and complex part considering the wide range of factors influencing the decision on which procurement system to use. In dealing with a similar difficulty with quality of construction, Kim and Atkin (1996) chose a multi-criteria approach to enable the trade-offs between cost and quality to be clearly identified. Multi-criteria decision making leaves the relative importance of the different factors to the user to determine in an unstructured manner.

Despite the multiple objectives of client and contractor, it is simpler to have just one value as a measure of the appropriateness of a system for decision making purposes.

The approach used here is to incorporate a large number of factors through an interaction matrix which determines their relative contributions and from this calculate a single value by which the possible procurement systems can be ranked taking into the account the client objectives and the characteristics of the project.

The factors influencing the decision are diverse and subject to varying emphasis on each project. Any system which attempts to take all these diverse requirements into account, should structure and formalise the influences of the factors if it is to be repeatable. The choice of an appropriate procurement system then stems from an informed decision based on the circumstances at the time.

The factors influencing the success of procurements were first categorised under three headings: client needs, project characteristics and procurement process system features. The following examples of the factors in each category include the main factors only to avoid complexity in the description. The selection methodology can be extended to include any number of factors in each category.

Client needs

A client may have more than one need in constructing a facility and choosing a procurement system. Obtaining the facility at the lowest cost may not be the primary aim. The objectives of a client are influenced by factors internal to the client, such as need for the investment, and external factors, such as the size of the project, the prevailing economic conditions and the competition in the construction market place. While Hashim (1997) categorised objectives under time, cost and quality, discussions in a CIIA workshop decided that the three main independent client objectives are:

- Time criticality,
- Cost criticality, and
- Client involvement.

The last may be an alternative view of quality in that where the client is involved, the required quality eventuates. Other objectives which the client may have and which could affect the choice of a procurement system include need to incorporate innovative design or practices, to appear better than competitors, to be familiar with (or understand) the procurement system, to provide transparent incentives to contractors and to ensure probity.

Project characteristics

A workshop of CIIA members looked at creating as small a list as possible of project characteristics which were as independent of each other as possible and which would enable all project types to be accommodated. The four most likely independent categories were:

- Level of complexity of the project,
- Repetitious nature of the process,
- Risk, and
- Scale.

The project characteristics, which affect the choice of a procurement system, could be split to include further categories of complexity and risk or increased by inclusion of quality or off-site manufacturing.

Procurement process system features

The participants in the CIIA workshop were also asked to visualise the perfect procurement environment. This assumed a truly external view on the problem, trying to put aside known obstacles and perceived impossibilities. The exercise was not designed to try and develop a solution, but rather what a procurement system would do. From this list and other information, a shorter list of procurement process system features was developed, again with the expectation that each would be independent of the others and yet representative of the wide range of factors upon which a procurement system is selected. Ten features identified as representative were:

- Complete documentation before construction,
- Cost predictability,
- On time deliverable,
- Quality guaranteed,
- Appropriate risk sharing,
- Client management/co-ordination responsibility,
- Competitive tendering,
- Contractor input into design,
- Team focus and non-adversarial approach, and
- Minimal variations.

ASSESSMENT METHODOLOGY

The proposed approach for a procedure to evaluate the appropriateness of a procurement system for a particular project together with the needs of the client assumes that there are three independent dimensions which influence the choice of a procurement system: client needs, project characteristics and procurement process features (Figure 2). The use of three dimensions implies that there is an interaction (or influence) between each category on each axis with each and every other category on the other two axes but not between themselves (assumption of independence of each category from each other category on that axis). Weightings which reflect the actual circumstances at the time determine the strengths of the interactions in a particular case.

Interaction matrix

The proposed evaluation method assumes that there is interaction between the three dimensions and that each category in each of the three dimensions has a different importance weighting dependent on the client, project and procurement system. The interaction matrix A_{cps} in the three dimensions (c=client, p=project and s=system) is determined once. However, any new client needs, project characteristics and procurement process system features can be added when required. The examples below use the three client needs, four project features and ten procurement process system features described above for illustration purposes only.

The values in the interaction matrix A_{cps} are a measure of the strengths of the interactions and are set as integers in the range from 0 to 10. The strengths of the interactions are determined subjectively from experience. To decide on a value, two factors are considered together and the strength of their combined influence on a factor in the third dimension determined on one category at a time, assuming that each factor is applied at full strength. The values were determined by asking the question: *How important to the combination of (say) cost criticality (at full strength) and (say) risk (at full strength) is competitive tendering in ensuring the success of the project?*

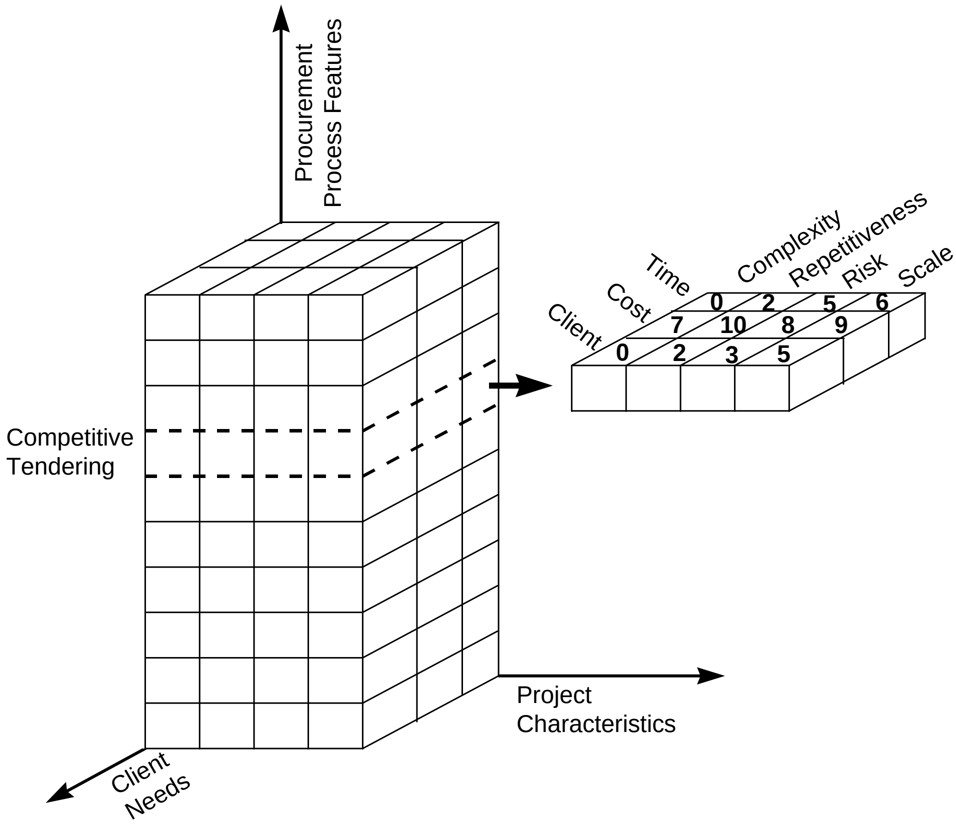

Figure 2: Three dimensions of influence in choice of a procurement system

The responses by individuals experienced in industry project management are then averaged to give a value which remains constant in the selection model until a new series of responses are obtained and included in the averages. This question must be repeated for all combinations of c, p and s to complete the interaction matrix A_{cps}. In the case of the example, the question must be asked and answered 3*4*10 times, i.e. 120 times to put a value in each block of Figure .

Weightings

The interaction matrix A_{cps} is a constant in the evaluation procedure. To evaluate a system for a particular set of circumstances, a series of weightings have to be determined by the user for the client needs, the project characteristics and the procurement system. The weightings for each procurement system are, like the interaction matrix, determined subjectively for each feature of a procurement system and are not required to be reassessed for each project.

For each project, the client needs and project characteristics must be evaluated. For each of the client needs, the user must rate their importance (N_c) to the particular project using a scale of 0 to 10, e.g. time criticality at 6, cost criticality at 9 and client involvement at 1. Similarly for the project characteristics, the user must rate their relative significance (C_p) using a scale of 0 to 10, e.g. complexity at 3, repetitiveness at 7, risk at 10 and scale at 4, as shown in Table 1.

For each procurement process system (n) to be evaluated, the capability of that procurement system to achieve each of its features (F_{ns}) in the list (10 in the example) must be rated on a scale of 0 to 10, e.g. a traditional system would rate near 10 for *all documentation before construction* and similarly for competitive tendering, while rating near zero for *contractor input to design*. This assessment is only done once. A

Table 1: Example weightings for client needs and project characteristics

Client Needs	**Weightings**
Time criticality	6
Cost criticality	9
Client Involvement	1
Project Factors	
Complexity	3
Repetitiveness	7
Risk	10
Scale	4

Table 2: Example weightings for procurement systems

"Traditional" procurement system	**Weightings**
Complete documentation	10
Cost predictability	9
On time deliverable	7
Quality guaranteed	5
Risk sharing	1
Client management	7
Competitive tendering	10
Contractor input	1
Team/ non-adversarial	1
Minimal variations	2

typical weighting scheme for the "traditional" procurement system is shown in Table 2. An additional weighting for each feature n, the importance factor I_n (normally = 1) allows for the significance of a feature to be changed for a particular project.

EVALUATION OF APPLICABILITY OF A PROCUREMENT SYSTEM

To score the suitability (S_n) of each procurement system n, the interactions are summed with the appropriate weightings, i.e.

$$S_n = \sum_{c,p,s} N_c C_p I_n F_{ns} A_{cps}$$

The procurement systems are then ranked in descending order of score (S_n). With the values of N_c, C_p and F_{ns} in the range 0 to 10, the total score is divided by 1000 to reduce the score to a value in the 100s.

The methodology for selecting an appropriate procurement method has been implemented in a prototype software package, which demonstrates how such a methodology may be used into a practical software tool for the construction industry. The software program has been developed in a Windows format and designed to allow quick assessment of a particular project with regard to procurement selection.

Not only is the total score required to enable a better understanding of why one system performs better than another, but does also show how well a system performs for each procurement feature. A graphical display for each procurement system, showing the individual scores for each procurement feature(s) that, once added together, determine the overall score (Figure 3) shows strengths and weaknesses. In Figure 3, the system assessed performed well in areas of documentation, cost predictability and competitive tendering, but performed very badly in contractor input.

Benefits

The benefits of using such as evaluation system include:

- quick and consistent assessment of alternatives,
- ensuring that a full range of objectives and project characteristics are considered,
- users having valuable information for determining whether this procurement system is appropriate for their job,

- strengths and weaknesses of a procurement system for a particular circumstance being made clear, and
- repeated application for each project or client educating users to the full range of options and reducing the need to choose the familiar, rather than the most appropriate procurement system.

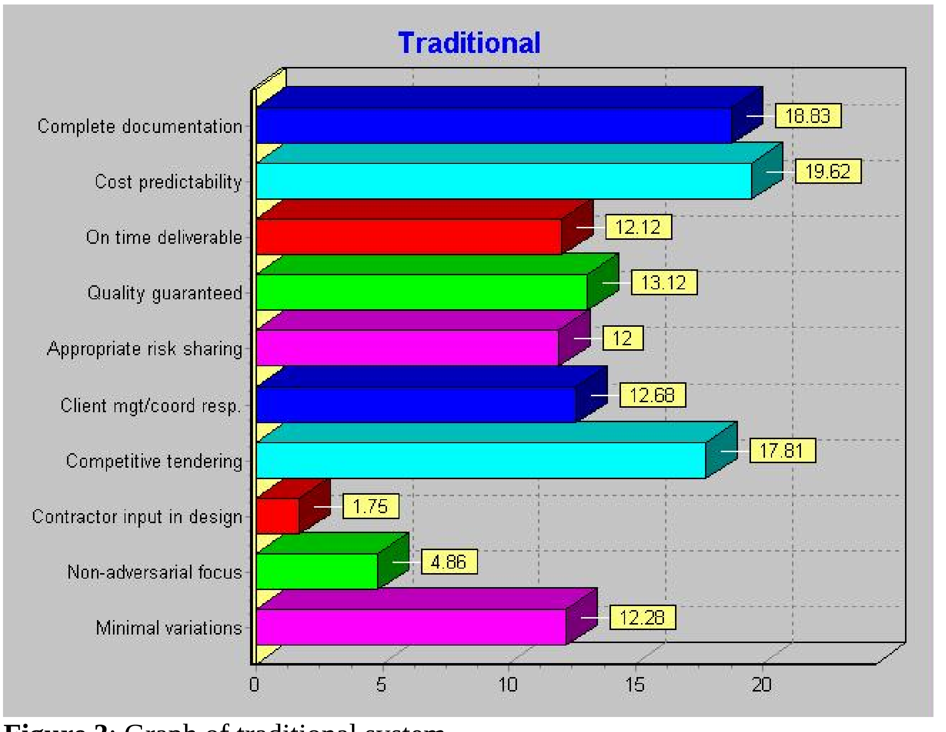

Figure 3: Graph of traditional system

CONCLUSION

The wharf project highlighted several areas which can cause problems in the design development phase of a project. 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 in regard to cost. Such a basic oversight may seem a rather simplistic solution, but demonstrates the importance of having in place an assessment process which takes into account *all* requirements.

Improving the procurement process depends upon having selected an appropriate procurement system specifically for the project. This does not necessarily mean that any of the existing systems cannot be the best solution; indeed many of the existing systems have strong features that are ideally suited to many projects. However, it is important to encourage development of new systems and provide tools which enable this to occur. This prototype software is one such tool which provides an effective way of determining procurement system performance for a particular project. Use of such an evaluation system can aid in developing innovative procurement systems and assessing their strengths and weaknesses. Desirable characteristics for existing procurement systems can be incorporated to form hybrid systems and help improve the construction delivery process.

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