Five case studies applying Soft Systems Methodology to Knowledge Management

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Abstract
Construction projects are faced with a challenge that must not be underestimated. These projects are increasingly becoming highly competitive, more complex, and difficult to manage. They become problems that are difficult to solve using traditional approaches. Soft Systems Methodology (SSM) is a systems approach that is used for analysis and problem solving in such complex and messy situations. SSM uses "systems thinking" in a cycle of action research, learning and reflection to help understand the various perceptions that exist in the minds of the different people involved in the situation. This paper examines the benefits of applying SSM to problems of knowledge management in construction project management, especially those situations that are challenging to understand and difficult to act upon. It includes five case studies of its use in dealing with the confusing situations that incorporate human, organizational and technical aspects.

Key words
Construction projects, knowledge management, complex systems, problem solving, Soft Systems Methodology.

1. Introduction

The issue of knowledge management in construction projects is a challenge that cannot be underestimated. Such projects are becoming more complex, they are subject to constant change, and the industry environment is highly competitive and cost critical. The challenge becomes greater where joint ventures, partnerships and sub-contracting agreements are involved. The ad hoc and tradition approaches to construction management often fail to perform in these situations, and managers need to consider adopting alternative approaches to solve these difficult problems.

Soft Systems Methodology (SSM) is a systems approach that is used for analysis and problem solving in complex and messy situations. SSM uses "systems thinking" in a cycle of action research, learning and reflection to help understand the various perceptions that exist in the minds of the different people involved in the situation. It is particularly suited to complex management systems, and seeks to evaluate as many different options as possible. This approach is applicable to many domains; including change management, planning for health and medical systems, information systems planning, human resource management, analysis of logistics systems, and expert systems development. More specifically, SSM is being used in research associated with knowledge management, project management, and engineering and construction management.

2. Soft Systems Methodology

Soft systems thinking seeks to explore the 'messy' problematic situations that arise in human activity. However, rather than reducing the complexity of the 'mess' so that it can be modelled mathematically (hard systems), soft systems strive to learn from the different perceptions that exist in the minds of the different people involved in the situation (Andrews, 2000). This interpretive approach is strongly influenced by Vickers' (1968, pp. 59, 176) description of the importance of appreciative systems in dealing with human complexity. Checkland (1999), and Checkland and Scholes (1990) have attempted to transform these ideas from systems theory into a practical methodology that is called Soft Systems Methodology (SSM). Checkland's premise is that systems analysts need to apply their craft to problems of complexity that are not well defined, and that SSM attempts to understand the wicked and fuzzy world of complex organisations. This is achieved with the core paradigm of learning (Checkland, 1999, p. 258).

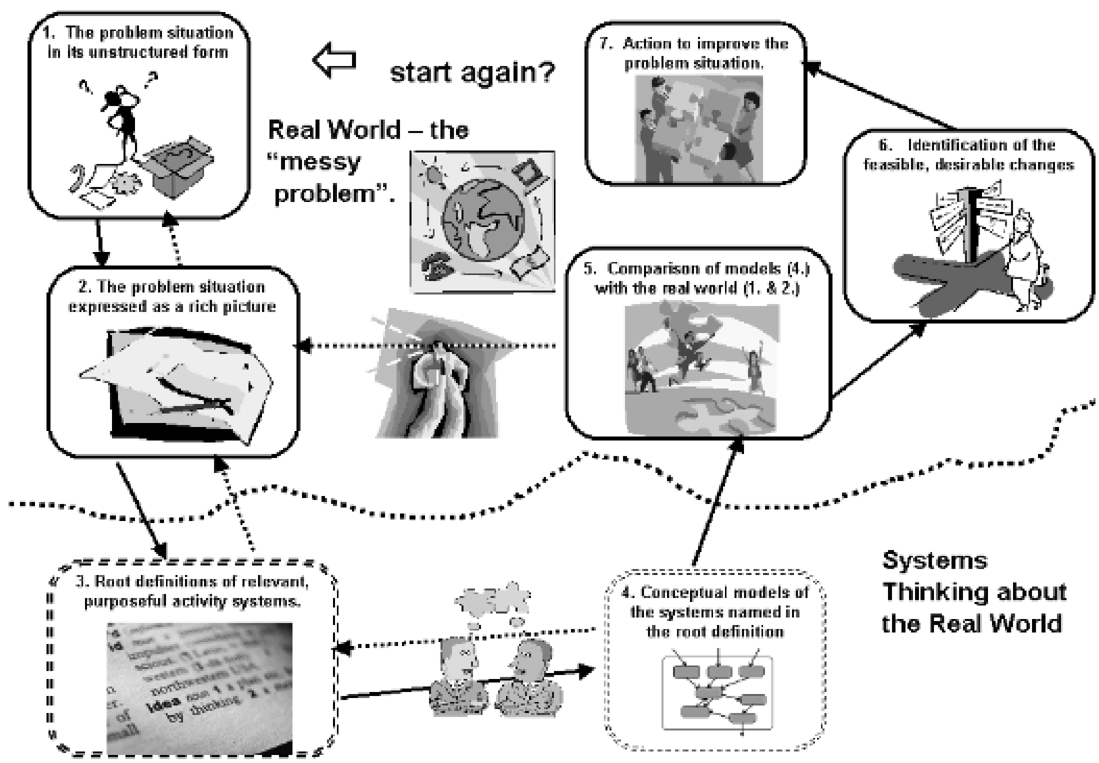

Figure 1. Summary of SSM as a seven-stage process
(Adapted from Checkland, 1999: pp. 163, and Checkland & Scholes, 1990: pp. 28)

Soft Systems Methodology (SSM) may be used to analyse any problem or situation, but it is most appropriate where the problem "cannot be formulated as a search for an efficient means of achieving a defined end; a problem in which ends, goals, purposes are themselves problematic" (Checkland, 1999, p. 316). Soft Systems Methodology, in its idealised form, is described as a logical sequence of seven steps (Checkland, 1999, pp. 162-183). These are illustrated in Figure 2.

It is most important to note that the sequence is not imposed upon the practitioner; a study can commence at any stage, with iteration and backtracking as essential components. SSM encourages investigators to view organisations from a cultural perspective. Therefore the component parts that are human beings determine the essential characteristics of organisations. These "people-components" can attribute meaning to their situation and define their own purpose for the organisation.

Industries with entrenched traditional structures, including the building, construction and engineering industries, are under particular pressure to review their working practices. In this context, Elliman and Orange (2000) recommend SSM as an approach to facilitate effective change and to improve work practice. In particular, SSM is able to stimulate debate and capture the vision for the future of participants. They observe that a soft systems approach allows the exploitation of individual and socially constructed group knowledge and experience. Green (1999) also identifies problems in the building and construction industries and suggests that the potential of SSM lies in the early stages of a project to assist stakeholders to achieve a common understanding of the problem situation. Cushman *et al.* (2002, p.3) observes that "Construction is ultimately a very complex, multi-disciplinary activity and there is a need to integrate the kind of design and management processes in terms of skill and the knowledge that people bring." To achieve this, Cushman *et al.* have used SSM's rich pictures and root definitions to identify responsible actors, key transformations, and the knowledge resources that are appropriate to the needs of a construction company. Venters *et al.* (2002) further describes how SSM can be used to develop conceptual models that identify patterns in knowledge activities. Such patterns can be used to provide a basis for technical design and organisational and social intervention. Based upon the need to address the wicked problems in the construction industry, the following model to apply SSM has been developed (Figure 3) and is being incorporated into investigations into innovation and knowledge management in the construction and building industry.

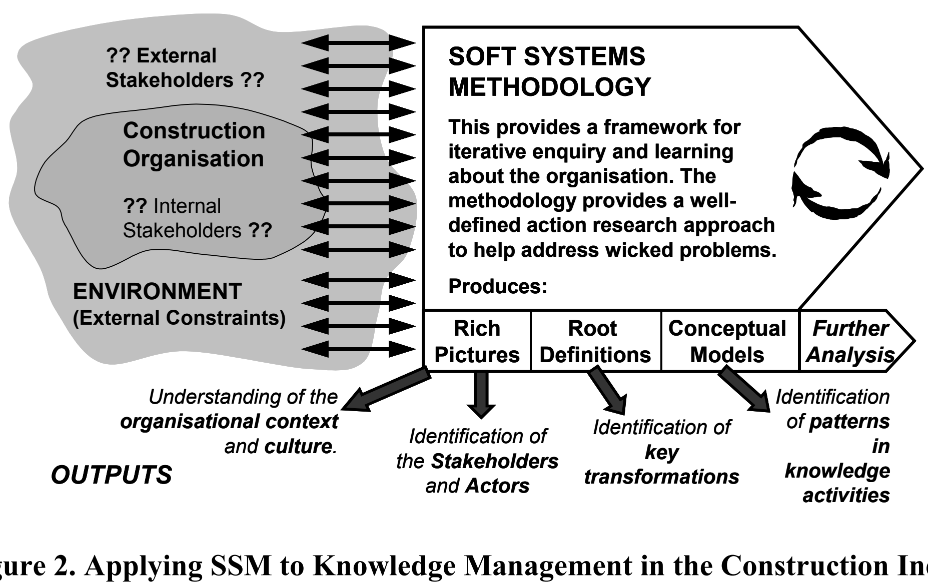

Figure 2. Applying SSM to Knowledge Management in the Construction Industry

3. Five Case Studies

3.1 Pretendering

A major Australian construction contractor company was chosen for the present study. As soft system methodology is helpful for knowledge elicitation in complex and poorly defined areas (Finegan, 1994), a particular organisational process was chosen which was less formal, rather complex and poorly defined. The process selected was "Pre-tendering" - the process by which this organisation makes an early decision to continue, or not, further venturing in a specific project. The pre-tendering approach doesn't exist in an explicit form; rather it depends on the team that informally undertakes it. It is a process that is embedded in the organisation routine and knowledge for carrying out this process mostly resides in the heads of the people in a tacit form. Therefore, pre-tendering presents a good example for illustrating knowledge management implications that are basically concerned with the capture/elicitation, codify, transfer and sharing of embedded, tacit knowledge.

In the case study, the pre-tendering process was usually undertaken by the team, however if an individual team member were to leave the organisation, the loss of tacit knowledge could seriously impact the efficiency of the process. In such circumstances it becomes necessary to make the knowledge involved in the process explicit. Difficulty can arise when attempting to capture related knowledge through a simple flow chart or other illustrating techniques. A flow chart cannot capture the context and does not provide insight into a system that contains interdependent human and technological components. Soft System Methodology serves as an important tool for knowledge elicitation in such circumstances as it aims at understanding the context in which the whole system functions (Finegan, 1994, 1995).

3.1.1 Applying Soft Systems Methodology to the case study

Undertaking the SSM stages as mentioned above, interviews with selected project team members were conducted to develop a rich picture. The objective was to learn about the structures, processes, perceptions and beliefs associated with the case study situation. Developing the rich picture is an iterative process, and to date we have carried out two iterations. The rich picture shown in the Figure 3 and conceptual model shown in Figure 4 represent the work-in-progress at this stage.

In first iteration, interviewees were asked informal, unstructured questions about their involvement in the pre-tendering process based upon their experience and expectations. They were asked to talk about their role and the important tasks that they have performed in the past. It was observed that some participants found it difficult to focus on the answers. This difficulty is normal and can occur when people try to verbalise their tacit thoughts. Therefore an important task of the interviewer was to keep the discussion within the topic and context of the study.

After the interviews, notes taken during the interview were utilised to develop a rich picture. Developing a rich picture is a creative skill and one of the researchers with experience in SSM "work-shopped" the rich picture development in collaboration with other researchers. The rich picture portrayed all the key players involved in the process and presented a structured view by putting into context the factors affecting the process (Figure 3).

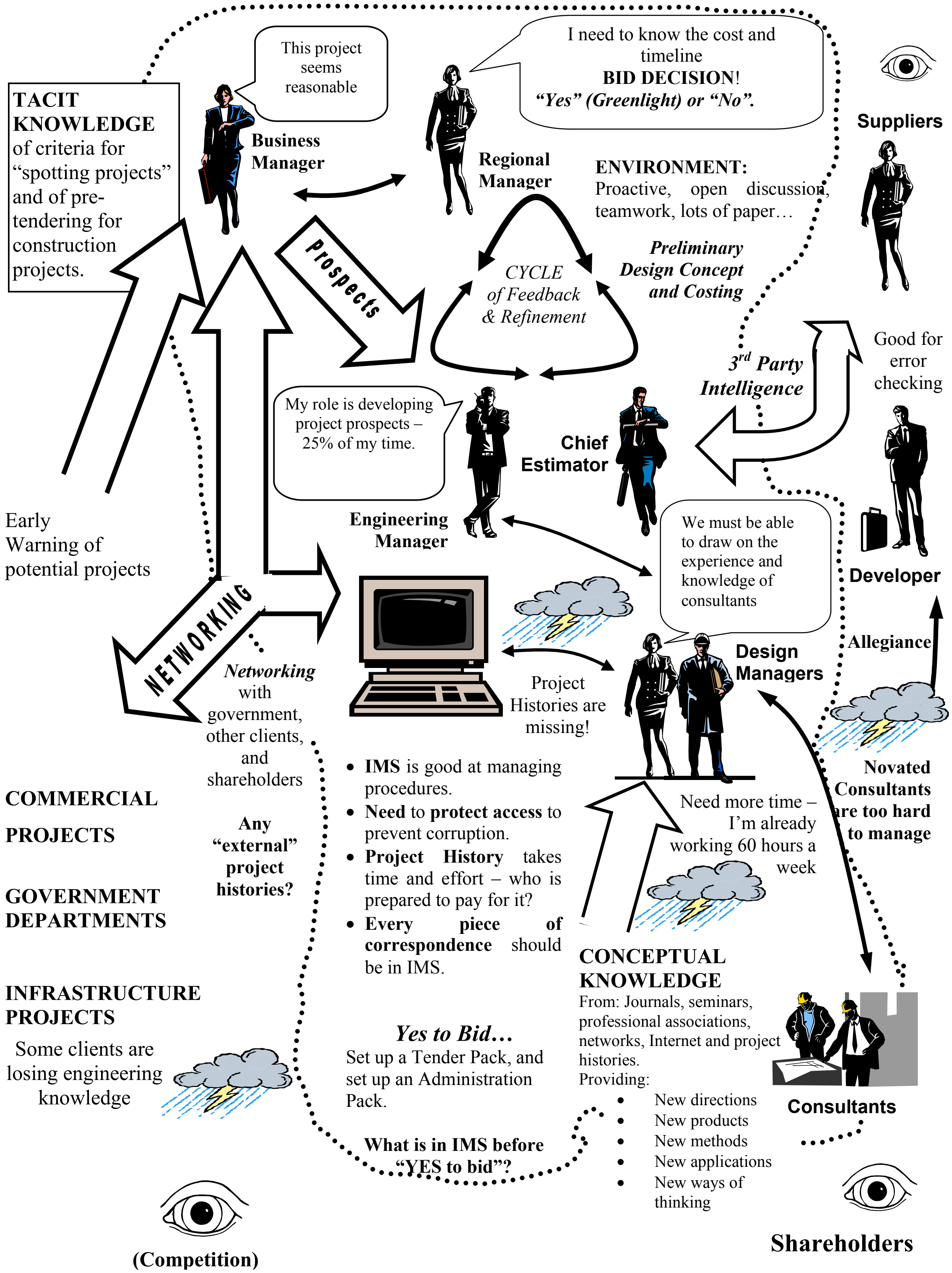

Figure 3: Rich picture Pre-tendering process

ROOT DEFINITION – **Pre-Tendering** A system owned by the pre-contracts team, who together with the Chief Estimator and the Design Managers, takes prospective projects from the Business Manager, together with knowledge, processes and technology, and prepares preliminary understanding of the project and cost estimates. This is used to assist the Regional Manager in assessing the feasibility of making a tender bid. This must be undertaken within short timeframes and with expert assistance from consultants. This is taking place in a very competitive environment where the "fit" to our business objectives and corporate goals, cost and the timeline are all important.	**Customer:** Regional Manager (RM) **Actors:** Engineering Manager, Chief Estimator, Design Manager, Pre-Contracts team, Business Manager. **Transformation:** Knowledge, processes and technology together with details of prospective projects, are used to prepare an understanding of the project and a cost estimate for assessing the feasibility of a tender bid. **Weltanschauung (why Bother?):** To assess the feasibility of making a tender bid, we (RM) need a good understanding of the project – does it fit our corporate objectives - and cost and timeline details. **Owner:** Pre-Contracts Team **Environment:** Competitive, quality, cost and time critical, community and corporate goals.

CONCEPTUAL MODEL – Pre-tendering

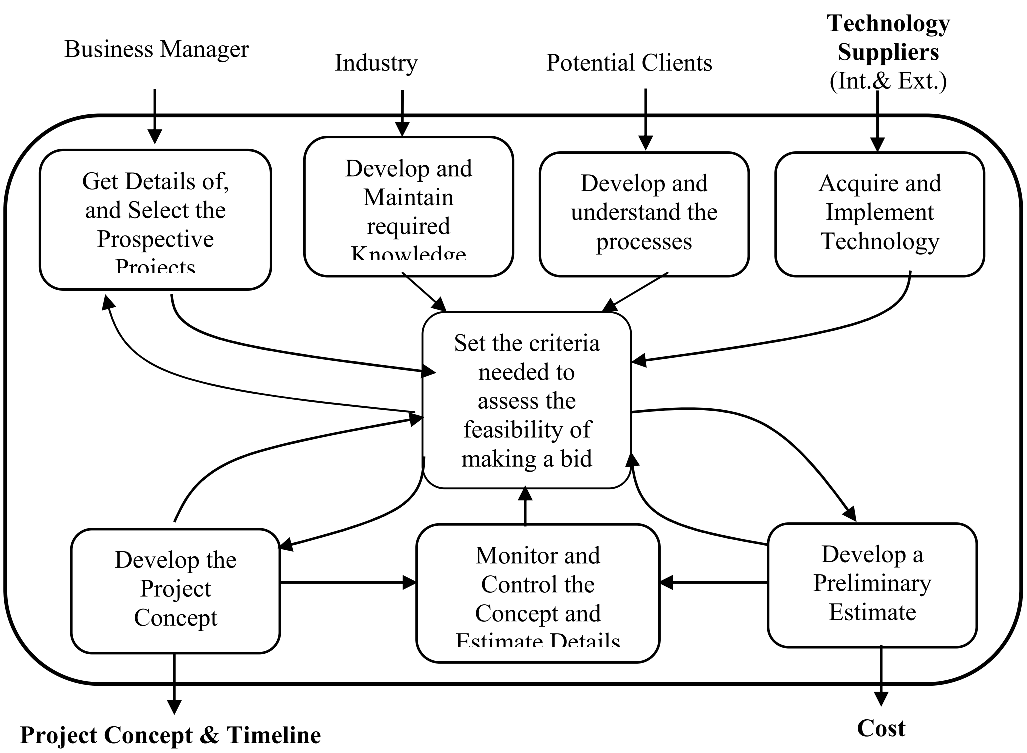

Figure 4: Root Definition, CATWOE and Conceptual Model of Pre-tendering Process.

The root definition, CATWOE and conceptual model were derived from the rich picture, then the initial version of rich picture and model were presented to a focus group of the pre-tendering team members. Participants of focus group, seeing themselves in a picture and interacting with each other were able to elicit further knowledge. One of the participants immediately came up with his own picture of how he interacted with other team members. This facilitated the refinement of the rich picture and conceptual model, and some of the confusion and misunderstanding that resulted from the initial interviews was resolved. With this enhanced understanding, especially of tacit knowledge, the researchers prepared the second iteration of the rich picture and conceptual model.

Figure 3 and Figure 4 shows the rich picture, CATWOE and conceptual model at the end of the second iteration. The research is an on-going and next step is to follow-up with the team members with more structured questions emerging out of the activities identified in the conceptual model and to continue with the SSM approach.

So far what we have accomplished using SSM is significant. The knowledge - which was embedded in the organisation routine and within individuals' beliefs and understandings in tacit form – has been captured and explicitly shown in a form of rich picture without loosing the context. Using SSM has provided us with an approach to help overcome the difficulty in working with tacit knowledge. It has helped to describe and express form to a process, which apparently had no previous formal structure within the organisation. In the words of one of the team members "You have helped formalise the process which has never been done before in our organisation' and "What we are doing here is distilling the facts". SSM not only helped in formalising the knowledge but also elicited areas of conflicts and problems associated with the process.

3.1.2 Knowledge elicited in Pre-tendering process

Key Players in the pre-tendering process were Regional Manager, Business Manager, Engineering Manager, Design Managers, and Chief Estimator. During the process they interact with people external to the organisation like developers, consultants and suppliers. This is illustrated in the rich picture (Figure 3) that shows the structure, processes and especially the beliefs and perceptions of the key players. Also shown are significant relationships, sources of knowledge, and significant concerns and perceived conflicts within the situation.

This rich picture is followed by the development of the root definition that provides the central transformation of the "ideal" pre-tendering system. In this case-study the transformation is defined as: "Knowledge, processes and technology together with details of prospective projects, are used to prepare an understanding of the project and a cost estimate for assessing the feasibility of a tender bid". This transformation is the basis for the development of the conceptual model of pre-tendering (Figure 4). This is expressed as a model of human activity where there are eight high-level key activities necessary to achieve the transformation. Of particular interest as candidates for further study are the three knowledge acquisition activities (or subsystems), the planning subsystem, and the management subsystem:

- Get details of, and select the prospective projects,
- Develop and maintain required knowledge,
- Develop and understand the processes,
- Set the criteria needed to assess the feasibility of making a bid, and
- Monitor and control the concept and estimate details.

The next stage of the research is to interview the participants again with structured questions that will emerge from key activities described by this conceptual model. This detailed information will form the basis of the comparison between the reality of the real world pre-tendering, and the "ideal" expressed by the conceptual model. This comparison – or gap analysis – provides the framework to focus on the issues and opportunities, examine assumptions, and better understand the dysfunctional behaviours/actions that need to be remedied. This stage will also provide a reality check for the analysis to date, and is the point where SSM initiates a process to rethink and re-analyse the underlying assumptions in order to identify the desirable and feasible options for change and improvement in the pre-tendering process. In this case study the complete utilisation of SSM would formalise the knowledge of the pre-tendering process in explicit form, highlight problematic areas and provide recommendations to improve the process.

3.2 Project Histories

3.2.1 Applying Soft Systems Methodology to the case study

The earlier "Pre-tendering" case study provided the basis for undertaking this case study in the same organisation. It strongly emerges that the Pre-tendering team places a very high value on the use of Project Histories so as to prepare a realistic preliminary estimate and concept of the project for which pre-tendering process is being carried out. Nevertheless, the effective use of Project Histories has been plagued with various issues that restrict the Pre-tendering team from effectively utilize them. The research team is of the opinion that it is worthwhile to further investigate the issues barring the effective utilisation of the Project Histories. The same approach as illustrated in previous case study was adopted to develop the Rich Picture (Figure 5), Root Definition and Conceptual Model (Figure 6).

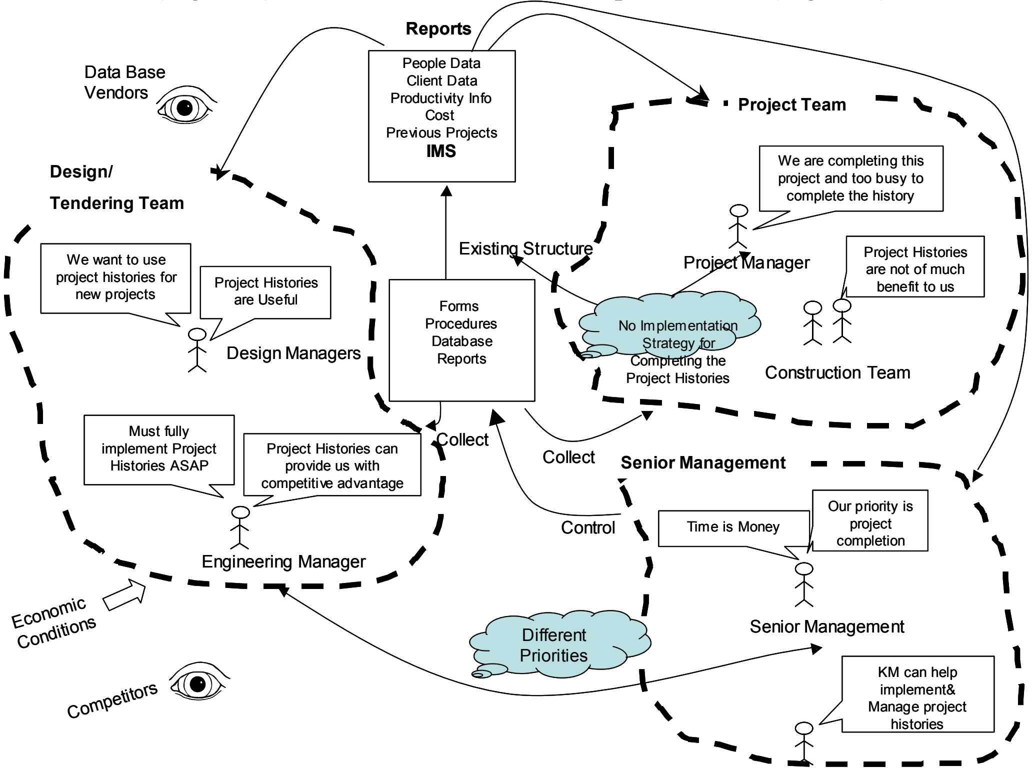

Figure 5: Rich Picture for Project Histories

Root Definition – Project Histories	
Root Definition – Project Histories A system owned by the Engineering Manager, who together with the Design Managers, seek data, information and knowledge from previous projects stored in project histories in order to prepare realistic preliminary understanding of the project and cost estimates for pre-tendering process and then for preparing the project bids.	**Customer:** Senior Management, Future Design Managers, Project Managers **Actors:** Engineering Manager, Design Managers, Project Managers, Construction Team **Transformation:** Knowledge, processes and technology together with details of past projects, are used to create and maintain a repository of a project histories that can be used when preparing a tender bid for a new project. **Weltanschauung (why bother?) :** To assess the feasibility of making a tender bid, a good understanding of the project is required based upon previous organisation experience and knowledge. **Owner:** Engineering Manager **Environment:** Competitive, Quality, Cost and time critical, Community and Corporate Goals.

Conceptual Model – Project Histories

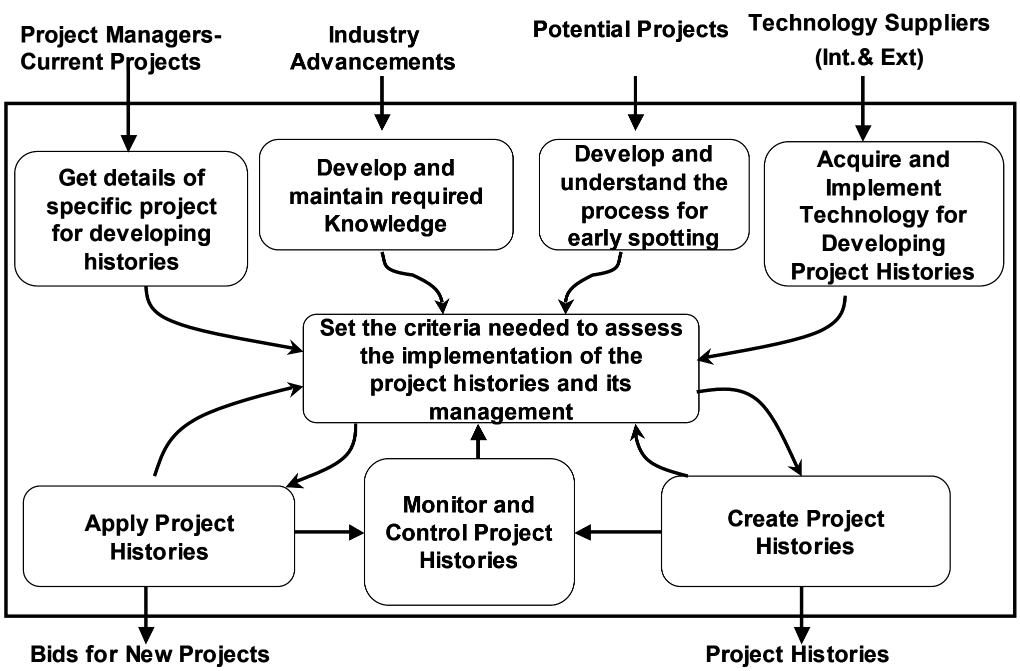

Figure 6: Root Definition, CATWOE and Conceptual Model of Project Histories

3.2.2 Knowledge elicited about Project Histories

Project Histories are basically the repositories/data bases that are developed to contain useful information and knowledge from the previous projects. In the organisation under study, the information, like productivity rates on previous projects, cost and timelines, and client details, mainly form the part of these repositories. These project histories are operated through an organisational ICT (Information and Communication Technology) system referred to as IMS (Information Management System). As one of the leading contractors company in Australia, the organisation under study has championed the use of ICT (since mid 1990's) as part of its commitment to become a Best-in-Practice organisation. IMS has become the general and most usual form of communication in the organisation and successfully been diffused with in the organisation even to the foreman level. Whereas IMS is effectively utilized while the project is in progress, it is rarely used to successfully develop and maintain a history when the project is finished.

Developing a history requires the sifting through of huge volumes of information generated while project is being executed, and identifying and sorting the information that may be of use on next projects. Though in project close-out procedures, project debriefing about the project just finished is done, it is often not sufficient to provide and record the useful information for future use. The lack of interest of the project team in participating in project debriefing further aggravates the problem and eventually, there is very little that is carried forward from a previous project to be used in future projects. Hence, most of the knowledge carried from one project to other remains "Tacit" – residing as knowledge of individuals. The success of project histories proliferation alone is highly unlikely, unless it is seen as a part of the some strategic and business philosophy like Knowledge Management.

The benefits that project histories can deliver are significant and very clear in the minds of the people who want to use them. However, as shown in the Rich Picture (Figure 5) this small group of people is less likely to influence the other functioning team members who have different priorities. As illustrated by the activities defined in the Conceptual Model (Figure 6) Knowledge Management places a great emphasis upon the project histories and see it as a mechanism whereby not only useful information is assorted and stored but efforts are made to turn "Tacit" knowledge of the individuals into "Explicit" and is disseminated to all others through these repositories. These repositories, then, contain lessons learnt, unique problem handling techniques devised by the individual when faced with problem on the project, etc so as to stop "Re-inventing the wheel" on the next project thus saving time and resources. Attaching the context of Knowledge Management to the scenario of project histories will give these histories a new vigour and framework for understanding by both senior management and the project team.

3.3 Bridge Project

3.3.1 Applying Soft Systems Methodology to the case study

After conducting the case study on "Project Histories", it was deemed necessary to further look for the cases that can successfully become part of the project histories and the lessons generated in those projects can be the effectively used in improving pre-tendering process on future projects. This case study documents the commonly observed scenario while tendering, where multiple parties try hard to bid on a certain project and only one with the lowest bid achieves success. This case study documents a tendering process on a Bridge Project where the bidder lost their bid by a very small margin. It was claimed by the bidder that with a little more expense, the client was going to get a lot more value out of the design. However, by disregarding value analysis and resorting to competitive bidding, the bid with the lowest price (with less value) was selected.

The case study, illustrated in the Rich Picture (Figure 7) also illustrates the difficulty that tendering team experienced throughout the tendering process due to the very short time available for preparing the bid, then to discover that they had failed to be successful by a very small margin. In this case, client had undertaken an investigation of the site in the previous 3 to 4 years, but had not completed a final design. It then became a task of the bidder to develop a realistic design in addition to the cost and time estimate that would form a bid within the short time span of 12 weeks. The routine method of bridge design and the typical construction method could not be used because of the nature of soil (clay) that was very difficult to compact. Also, the presence of wild life sanctuary in the vicinity of the bridge made the design and construction environmentally sensitive and subject to community interest. To achieve a suitable solution all the team worked strenuously and developed a realistic design, cost and timeline, and bid was submitted. The bid was eventually lost by a very little margin, much to the disgust of the bidding team and especially the design manager. The project team shared the experience gained in developing this bid, adding to their tacit knowledge. By applying SSM, this experience has been made explicit and is documented in the Rich Picture (Figure 7), and Root Definition and Conceptual Model in Figure 8.

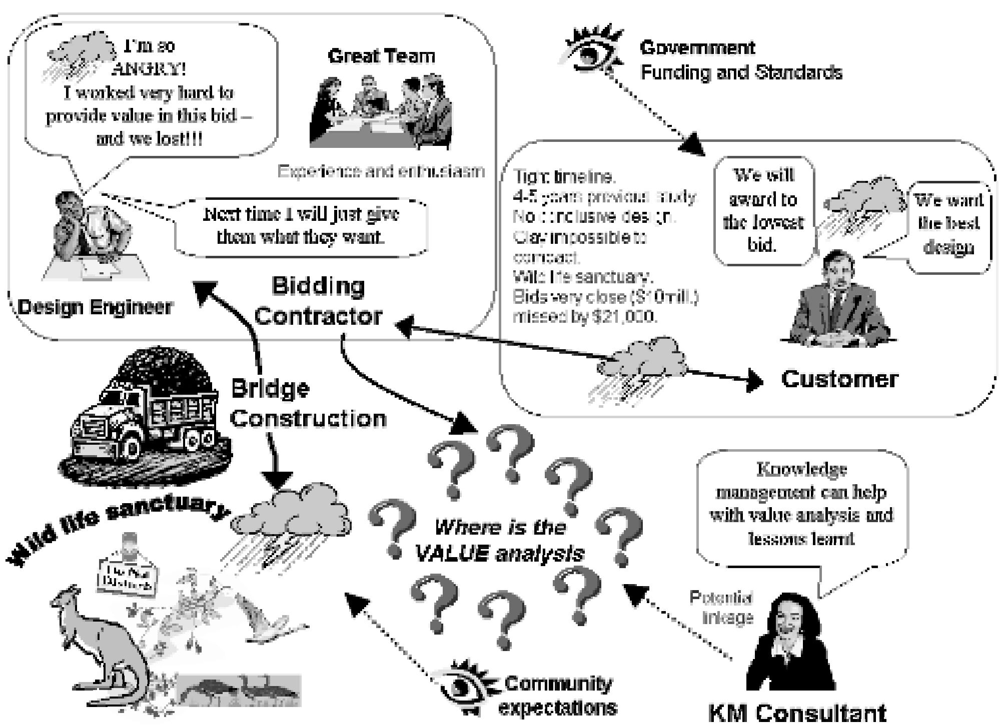

Figure 7: Rich Picture of the Bridge Project

ROOT DEFINITION – Bridge Project A system owned by the Bidding Contractor, who together with the Design Engineer, use knowledge, skills and experience to prepare competitive bids for the design and construction of bridge projects. This is undertaken with the understanding that while the client wants a low price, there is also a desire to obtain the best value in a bid. These bids must also take into consideration the competitive market and community expectations for the design and construction of a major project.	**Customer:** The client and the community **Actors:** Bidding contractor, competitors, design engineer, design team, client. **Transformation:** To use knowledge, skills and experience to prepare competitive bids for the design and construction of bridge projects. **Weltanschauung (why Bother?):** While the client wants a low price, there is also a desire to obtain the best value in a bid. **Owner:** Bidding Contractor **Environment:** Competitive, quality, cost and time critical, and community expectations.

CONCEPTUAL MODEL – THE BRIDGE PROJECT

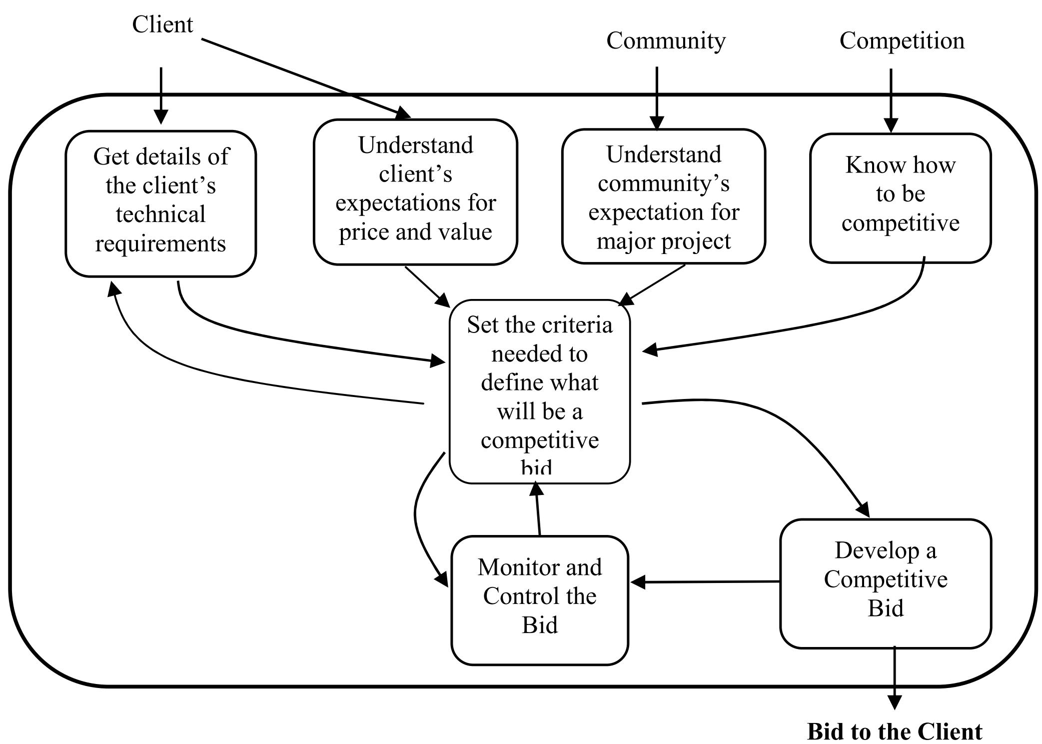

Figure 8: Root Definition, CATWOE and Conceptual Model of the Bridge Project.

3.3.2 Knowledge elicited about the Bridge Project.

The case study elicited various kinds of knowledge. For example, the deficiencies on the part of the client who were not able to complete a design of their own after 3-4 years of the study of the project. Also, that the value analysis was disregarded, allowing the client to select the lowest bid that offered comparatively lesser value in comparison with the second lowest bid.

This strengthens the case for devising a criteria based not solely on the lowest quoted price, but also on the value that a bid provides. This issue of value management is an important topic of ongoing research in construction practice.

The case study also documents how the design manager learnt the lesson by working very hard on a project, and then failing to get a bid. He then promised himself not to work so hard in terms of providing value while making bid for future projects. As in his own words “Next time I will give them what they want”, echoes the fact that he would not be performing innovatively on the future projects and would rather stick to the conventional approach. This reality goes against the vision of the construction industry, which looks forward to becoming innovative and modernised to get rid of notoriously low productivity levels. In terms of knowledge management, by documenting and disseminating the knowledge and lessons learnt in this case study, it is possible to improve the bidding on the future projects.

3.4 Road Project

3.4.1 Applying Soft Systems Methodology to the case study

This case study documents the process of tendering/bidding on a road project where it was required to construct the culverts to manage the flow of water. The rich picture in Figure 9 describes the problematic situation. Flood modelling was the basis for the selection of size and spacing of the culverts and this aspect was mostly covered in this case study. The design and construction method itself were of routine nature and were not investigated.

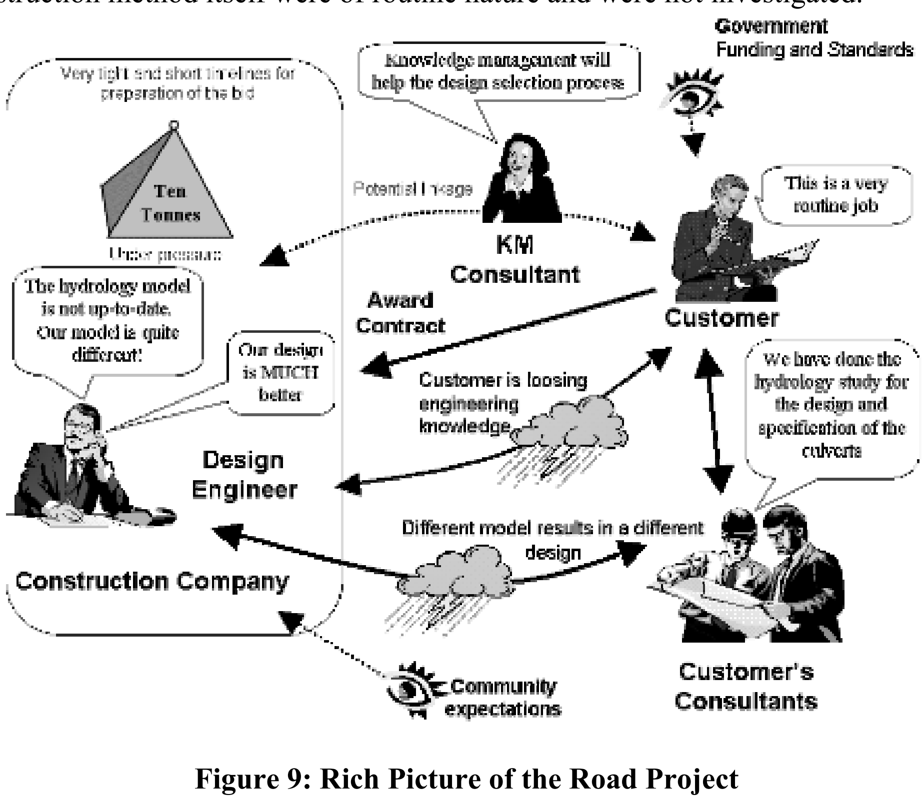

Figure 9: Rich Picture of the Road Project

ROOT DEFINITION – ROAD PROJECT A system owned by the Construction Company, who together with the Design Engineer, use knowledge, skills and experience to prepare competitive designs that delivers the most appropriate solution for the project. This is undertaken where the client may be loosing engineering knowledge and the client's consultants have not provided the optimal design parameters. These bids must also take into consideration the competitive market and community expectations for the design and construction of a major project.	**Customer:** The client and the community **Actors:** Construction company, design engineer, client, client's consultants. **Transformation:** To use knowledge, skills and experience to prepare competitive designs that delivers the most appropriate solution for the project. **Weltanschauung (why Bother?):** the client may be loosing engineering knowledge and the client's consultants have not provided the optimal design parameters. **Owner:** Construction Company **Environment:** Competitive, quality, cost and time critical, and community expectations.

CONCEPTUAL MODEL – THE ROAD PROJECT

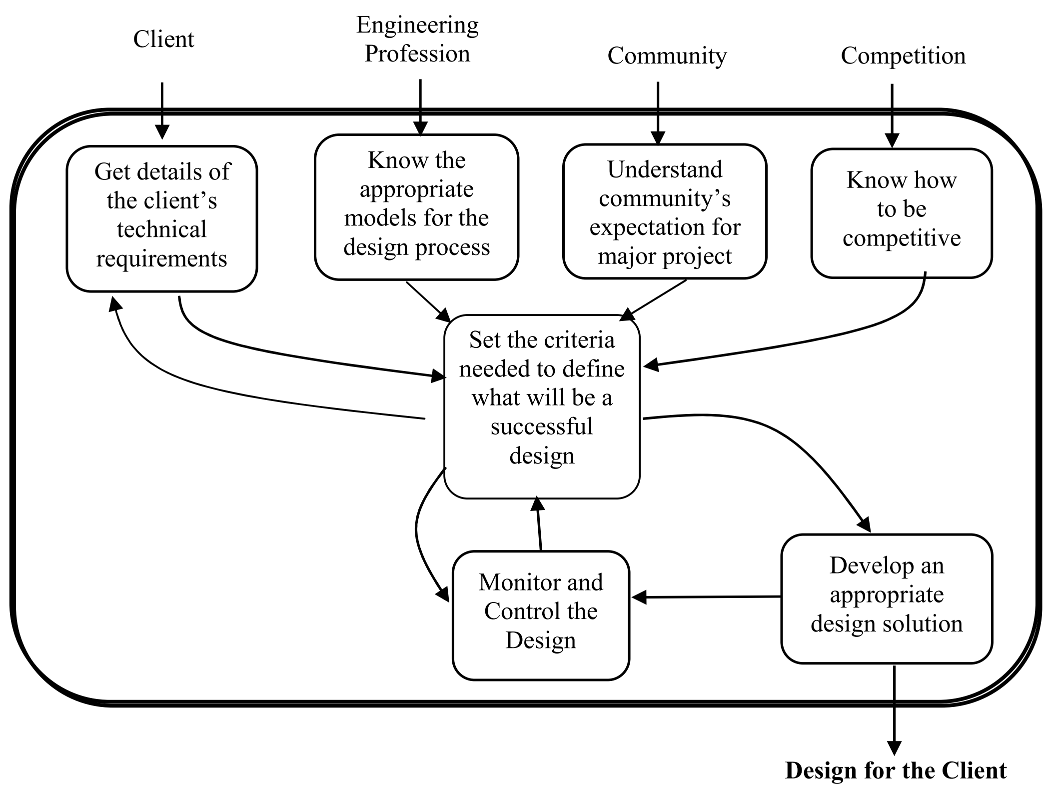

Figure 10: Root Definition, CATWOE and Conceptual Model of the Road Project.

3.4.2 Knowledge elicited about the Road Project.

Client has carried out the hydrological study of the area almost five years ago and based on their subsequent flood modelling they allocated the space and sizing of the culverts and hence initiated a bid process. The organization under study was one of the bidders and didn't agree with the sizing and spacing of the culverts as provided by the client. The bidding organization carried out their own flood modelling and challenged the client's specification for culverts based on the new model and the design properties derived from it. They completed their study under severe time pressure and were able to convince the client of their sizing and spacing, and eventually produced significant cost savings on the whole project. Figure 10 describes the Root Definitions and Conceptual Model for this case study. The knowledge gained in this process can significantly help the pre-tendering process. It explains in a explicit fashion that client may not be right all the time and sometimes it is worthwhile to explore alternative options. That the client is loosing the engineering knowledge is an important insight achieved by the bidding organization. From client's point of view, the explicit fact is that they need to strengthen their technical base.

3.4 BAMTEC innovation diffusion case study

The case study specifically describes the adoption and diffusion process of an innovative product called "Bamtec" in the organization under study. The technical nature of the product is immaterial to the execution of this case study. The most important issue is to know that the process behind the proliferation of such an innovation in the organization so as to know how it was adopted and diffused. Issues like adoption of innovation and its diffusion are central to the core of knowledge management. Knowledge Management helps in spotting such innovation that have the potential to improve the productivity and then provides a framework to adopt and diffuse that innovation through out the organization in order to reap benefits from that innovation.

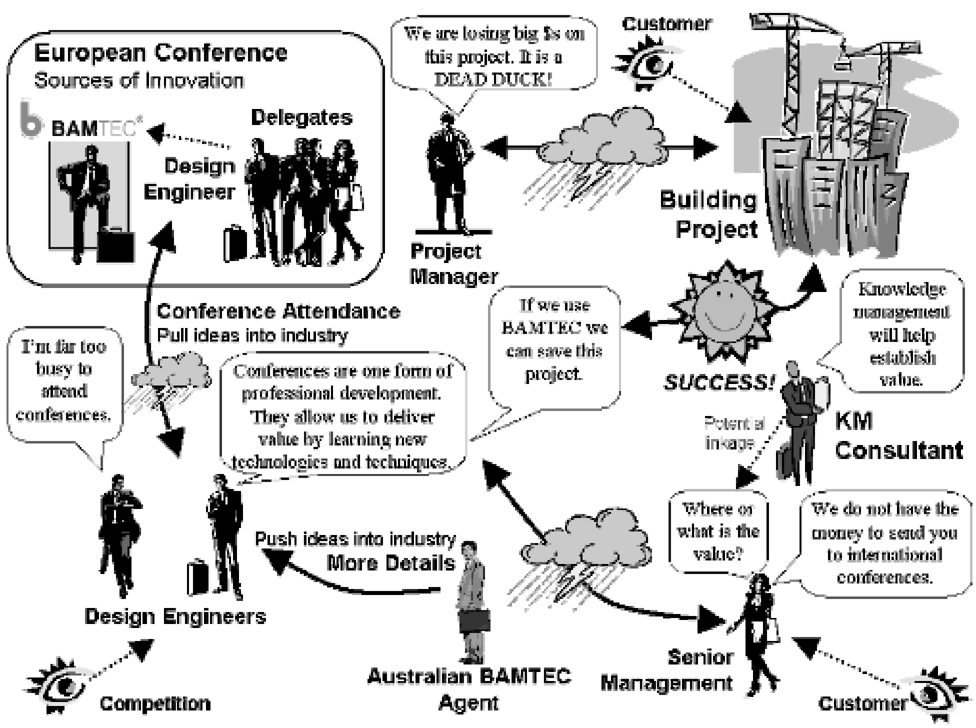

Figure 11: Rich Picture of the BAMTEC study

ROOT DEFINITION – BAMTEC	**Customer:** The building company, project managers, the clients and the community.
A system owned by the Design Engineers, who with the support of Senior Management are able to achieve professional development and learn new ideas and techniques by attending major, international conferences. This adoption of innovative building techniques can be the key to project success. However, Senior Management need to be convinced of the value of conference attendance, and many design engineers consider themselves to be too busy to attend conferences.	**Actors:** Design engineer, senior management. **Transformation:** To achieve professional development and learn new ideas and techniques by attending major, international conferences. **Weltanschauung (why Bother?):** This adoption of innovative building techniques can be the key to project success. **Owner:** Design engineer **Environment:** Work pressure, cost and time critical, and community expectations.

CONCEPTUAL MODEL – THE BAMTEC PROJECT

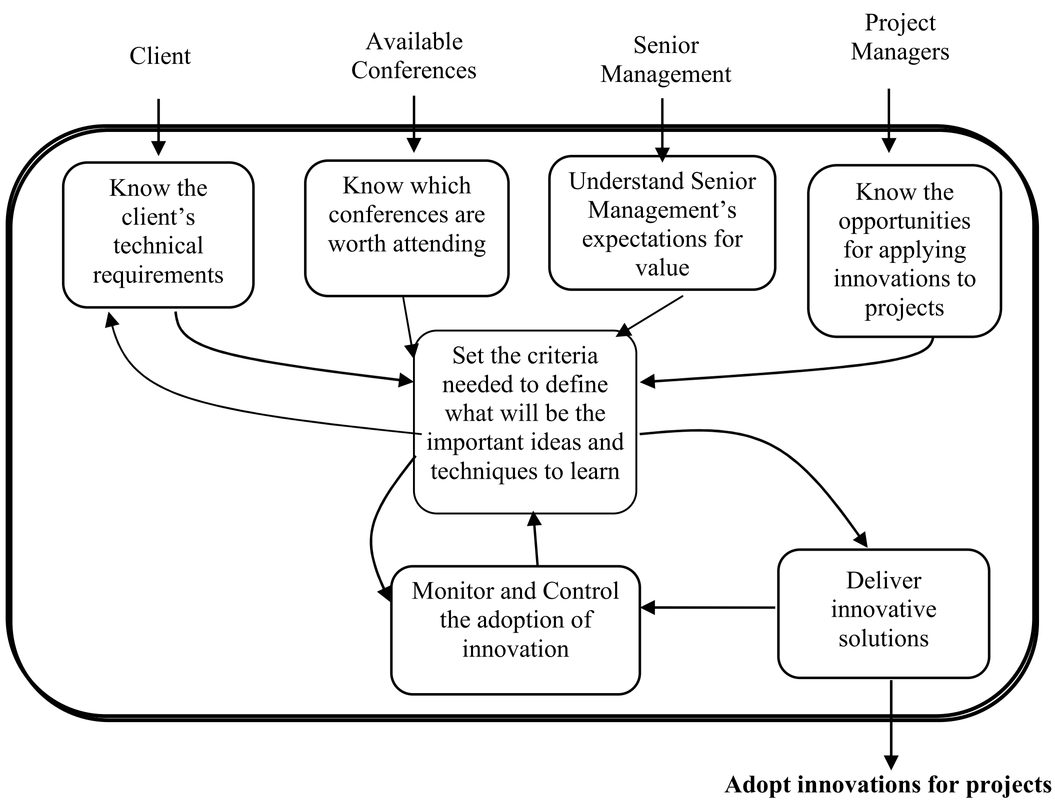

Figure 12: Root Definition, CATWOE and Conceptual Model of the BAMTEC study.

The rich picture in Figure 11 highlights a pictorial representation of the related processes. The innovative product under study was displayed at a European construction conference. This conference was attended by one of the design managers from the organization under study. The rich picture documents the values and beliefs usually existing in the organization. For some, attending conferences is not an important deal but some others take it seriously and have expectations that their organization to allow them attend such events on a regular basis. In this case, design manager implemented the use of the BAMTEC product in a project that previously had been declared as a “dead duck”. It was the sort of the project that was running over budget but not returning any profit to the organization. Implementing the BAMTEC product on the project - in the words of the design managers - “literally” saved the project and pushed it towards a profitable outcome. Knowledge Management may help make these events happen on regular basis. The root definition and conceptual model shown in Figure 12 give an explicit description of how a specific innovation can be adopted and diffused and can be effectively utilized for the benefit of the organization.

4. Conclusions And Further Work

This paper has illustrated the approach of applying SSM to problems in construction project management, especially those knowledge management problems that are challenging to understand and difficult to act upon. It includes five case studies of its use in dealing with the confusing situations that incorporate human, organizational and technical aspects. SSM encourages group learning and is ideal as a group decision-making approach. It is strengthened by the active participation by different participants and stakeholders, and encourages joint ownership of the problem solving process. Finally, SSM is recommended where an organisation is seeking to achieve changes in workplace culture and transformation into a learning organisation.

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