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STRATEGIC IMPLEMENTATION OF IT/IS PROJECTS IN CONSTRUCTION: A CASE STUDY

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ABSTRACT
The need for improved implementation of Information Technology (IT) and Information Systems (IS) has been emphasised in both empirical and prescriptive research studies. This paper presents a strategic implementation framework for IT/IS projects in construction. The framework builds upon recent published works and encompasses well-documented predictors for effective IT/IS implementation. A case study with a large multi-national construction organisation is used to demonstrate the strategic implementation of a Project Management Information System (PMIS) used for the first time in the construction of a mobile phone telecommunications network in the South East of Queensland, Australia.

KEYWORDS
Information Technology; Information Systems; SWOT Analysis; Analytical Hierarchy Process

1. INTRODUCTION

The successful implementation of new and innovative Information Technology (IT) and Information Systems (IS) in construction requires the development of strategic implementation plans prior to IT/IS project commencement (Betts, 1999). Unfortunately, little regard has been given to the future potential of IT/IS, giving rise to a large gap between output and expectation from these IT/IS investments (Dos Santos and Sussman, 2000). Only recently, there has been growing interest in developing planning frameworks to aid the strategic implementation of IT/IS in construction. Miozzo et al, (1998) derived an IT/IS-enabled process strategy for construction. Their research looks at a number of construction processes and 'blocking' sources to their efficiency. Jung and Gibson (1999) developed a framework for measuring and assessing Computer Integrated Construction (CIC) planning. They detailed five measures for CIC planning: (1) corporate strategy; (2) management; (3) computer systems; (4) IT, and (5) incremental investment. Pena-Mora et al, (1999) developed a strategic IT planning framework for the AEC industry, particularly focusing on large-scale construction projects. The first step in this framework is to understand the businesses of the AEC project as well as the dynamics of the overall economic environment in which the project operates. The second step is to analyse the relevant processes and functions within the AEC project. Finally, the third step is to develop an IT investment model that can be integrated into the overall strategic planning framework to devise the generic dynamic strategic plan.

This paper attempts to build on the above mentioned frameworks by introducing a strategic IT/IS implementation framework which is based on a critical assessment of market opportunities and threats, and organisational strengths

and weaknesses (see Figure 1). The paper presents the framework in a detailed step-by-step methodology supported by the ten well-documented predictors for effective IT/IS implementation (Gottschalk, 1999). A case study is also introduced where the proposed framework is used for the implementation of a new Project Management Information System (PMIS) by a large multi-national construction organisation in Australia. To oversee the implementation of the proposed framework, the paper suggests establishing a cross-functional team of staff members to form the IT/IS Review Committee (RC). This is to bridge the differing worldviews of senior managers and IT/IS professionals and to reinforce the message that all employees are working for the same goal: to achieve corporate objectives (Dos Santos and Sussman, 2000).

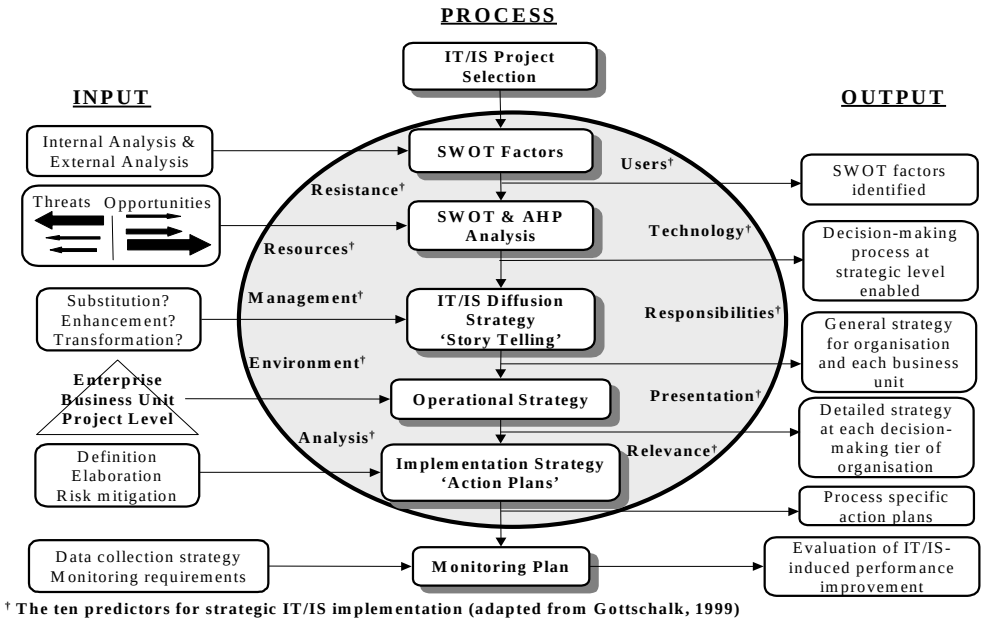

Figure 1: Strategic IT/IS Implementation Framework

2. STEP 1: SWOT FACTORS

Central to this step is the incorporation of the *scale of values* of the corporate management of the organisation (eg. objectives, perceptions, beliefs and challenges). This activity is important because it defines the way the organisation is managed and the criteria under which strategies are evaluated. Keeping in mind the *scale of values* of the organisation's corporate management, the RC needs to undertake an external and internal analysis. The former examines the environment in which the organisation is participating to study the potential opportunities and threats whereas the latter identifies the weaknesses and strengths of the organisation. Combining the results of the external and internal analysis and taking into account the *scale of values*, the SWOT (Strengths, Weaknesses, Opportunities, and Threats) factors are identified.

2.1 External Environment Analysis

The changing business environment and increased IT/IS capabilities are translating into more focused emphasis on strategic integration (Ahmad et al, 1995). Increased global competition on one hand and availability of communication-tools on the other, have enhanced opportunities for design and construction organisations to establish joint ventures, partnering and long-term relationships with clients and/or suppliers. Therefore, the main purpose of this analysis is to identify IT/IS-enabled integration and alliancing opportunities/threats. It is not sufficient though to concentrate the external analysis at the macroscopic level of the industry alone (Pena-Mora et al, 1999). This is because even at the microscopic level of construction projects, IT/IS spending has grown rapidly with operations and maintenance costs dominating the budget.

2.2 Internal Environment Analysis

Several researchers have articulated the need to consider how the internal organisational environment is determinant of the strategic IT/IS implementation planning process. For example, the organisation's corporate culture can

facilitate its strategic IT/IS planning by being congruent with it (Appelgate et al, 1996). The organisation's planning and control style, is perhaps in part a function of corporate culture, similarly influences strategic IT/IS implementation planning (Earl, 1996). Likewise, organisational size, organisational structure (mechanistic vs. organic) and management style (entrepreneurial vs. conservative) may influence strategic IT/IS implementation planning (Doukidis et al, 1994). The primary role of the internal analysis is to identify the weaknesses and strengths of the organisation. By collating all the opportunities and threats obtained through external analysis, combined with strengths and weaknesses obtained through internal analysis the organisation can undertake SWOT analysis as explained below.

3. STEP 2: SWOT ANALYSIS

Internal strengths and weaknesses, as well as external opportunities and threats obtained in step one form the foundation of SWOT analysis. SWOT analysis is a commonly used tool for analysing internal and external environments in order to attain a systematic approach and support for a design situation (Wheelan and Hunger, 1995). There is no standard list of factors that apply for all construction organisations because of the specificity of each set. However, strengths tend to relate to the competitive advantages and other distinguishing competencies, which can be exploited by the organisation on the market. Weaknesses are limitations which hinder the process of an organisation in a certain direction. Opportunities relate, for example, to the technology enabled advantages that can be obtained by the uptake of IT/IS. Threats relate to an array of macroscopic and microscopic problems that exist or may arise which can potentially jeopardise the successful implementation of proposed IT/IS projects.

If used correctly, SWOT can provide a good basis for successful IT/IS implementation strategy formulation. When undertaking SWOT, the analysis lacks the possibility of comprehensively appraising the strategic decision-making situation; merely pinpointing the number of factors in strength, weakness, opportunity or threat groups. In addition, SWOT includes no means of analytically determining the importance of factors or of assessing the fit between SWOT factors and decision alternatives. Thus, it can be concluded that the result of SWOT analysis is too often only a superficial and imprecise listing or an incomplete qualitative examination of internal and external factors. This gives rise to the need of a more efficient use of SWOT as argued by McDonald (1993).

The Analytical Hierarchy Process (AHP) is deemed the most appropriate analytical method for development of a hybrid method with SWOT. AHP is an effective tool in structuring and modelling multi-criteria problems and has been successfully used in a variety of construction management applications (Mohamed and Stewart, 2001). The idea in utilising AHP within a SWOT framework is to systematically evaluate SWOT factors and commensurate their intensities, adding value to SWOT analysis. This value can be achieved by pairwise comparison between SWOT factors and analysing them by means of the eigenvalue technique as applied in AHP. This offers a good basis for examining the present or anticipated situation more comprehensively. After carrying out these comparisons, decision-makers will have quantitative information about the decision-making situation; for example, whether there is a specific weakness requiring all the attention, or if the organisation is expected to be faced with future threats exceeding the organisation's combined opportunities. The reported case study details the use of the AHP/SWOT hybrid model for the weighting of strategic SWOT factors.

4. STEP 3: IT/IS DIFFUSION STRATEGY 'STORY TELLING'

To develop an effective IT/IS diffusion strategy, the information sought and gathered in the previous step must be carefully analysed, and recommendations that result from this analysis must be reviewed by all that have a vested interest in those recommendations. One powerful tool for structuring this critical analysis is called 'story telling'. Proponents suggest that story telling forces planners to think through their recommendations and helps build support for the implementation efforts that are to follow (Shaw et al, 1998). The work of Goldratt (1992), studied by both scholars and practitioners underscores the power of a story. Although fictional, and not written as a strategic plan treatise per se, *The Goal* (Goldratt, 1992), illustrates the heuristic power of a drama depicting human foibles in the pursuit of organisational excellence. This same heuristic power can be created when teams are brought together to plan for the integration of IT/IS (Dos Santos and Sussman, 2000). Story telling provides both a method and a forum for the team to think through the changes necessary to facilitate implementing the IT/IS system and at the same time, address the resistance to change that might be encountered.

The story should clearly describe how the proposed project will benefit the organisation (tie-in to the organisations strategy and plans), how organisational assets and processes will be affected by the new IT/IS project and what changes will be necessary to take full advantage of the IT/IS project's capabilities (substitution, enhancement, transformation). Also, the story must convey not just proposals for changes in structure, people and tasks deemed necessary to make best use of the system, but the logic behind their recommendations. Story telling builds on external and internal factors examined in SWOT analysis by treating strategy as an evolving drama incorporating the most likely forces affecting the intended outcome of the story ie. goal.

5. STEP 4: OPERATIONAL STRATEGY

From the IT/IS diffusion strategy, the operational strategy is derived. Stories formulated in the previous step are developed into a more detailed operational strategy, which considers each decision-making tier of the construction organisation (ie. project, business unit and enterprise tiers). Development of an operational strategy corresponds to the codification ie. the clarification and expression of strategies in terms sufficiently clear to render them formally operational. In developing an operational strategy, the chosen scenarios established by 'story telling' should be analysed in terms of functions (business systems), hierarchies and responsibilities (organisational structure), as well as in terms of the technical architecture required for the building of IT/IS systems that would support the alternative growth strategies. Hence, in this step various models of the target organisation should be elaborated: a functional model depicting IT/IS deployment; an organisational model depicting the responsibilities and hierarchies; and a technical model depicting IT/IS specifications ie. network requirements, software and hardware requirements, security, etc.

6. STEP 5: IMPLEMENTATION STRATEGY 'ACTION PLANS'

The implementation strategy is the most detailed component of the proposed strategic IT/IS implementation framework. This step requires the definition of robust actions, the evaluation of budgetary requirements, the study of time and organisational constraints, the elaboration of human resource issues, management and plan coordination, migration and diffusion etc. In addition, the action plans need to be examined concerning its risks, strategic importance and harmonised integration within the overall evolution of the specific organisation. There are three main stages to the development of the implementation strategy: (1) definition of action plan elements, (2) elaboration of action plan, and (3) risk mitigation and coping strategies.

7. STEP 6: MONITORING PLAN

Developing a strategic implementation plan for IT/IS projects does not guarantee their successful implementation. Consideration should be given to the continual performance monitoring of the implemented IT/IS project over its lifecycle. The IT/IS monitoring plan should consider performance measures and data collection strategies required for each IT/IS project implemented by the organisation. Applying the measurement concept to construction is not as straightforward as it is for the manufacturing sector where a clear 'bottom line' exists. To assess IT/IS-induced performance improvement, one must select an easily definable and limited number of performance measures with a mix of short and long-term goals. Traditionally, managers have only focused on the economic returns of an IT/IS investment (Stewart and Mohamed, 2001). A number of theoretical and practical IT/IS performance monitoring and evaluation frameworks are recommended for this purpose (Tucker et al, 1999; Marsh and Flanagan, 2000).

8. CASE STUDY

8.1 Description

ABC is one of Australia's leading providers of power, transport, defence and telecommunications infrastructure with an annual turnover in excess of A$1.7 billion. ABC was awarded the A$20 million contract to supply and construct an 1800 mobile phone network in the region stretching from the city of Gold Coast to Brisbane, in Queensland, Australia. This contract involved the site acquisition, design, supply and building of approximately 120 antenna sites throughout this region. The numerous sites being managed necessitated a better information management system to

handle the large quantity of text and visual information associated with each site location. In order to facilitate more effective management of project information and to address project communication requirements, the telecommunications division of ABC proposed to implement a Project Management Information System (PMIS) on this project. The proposed PMIS can be used to instantly share, visualise and communicate project information amongst project participants including staff, clients, consultants, subcontractors, suppliers and authorities. The aim of this case study is to report on adopting the proposed framework to facilitate implementation of the PMIS. ABC established an IT/IS Review Committee (RC) consisting of seven members: (1) project manager; (2) civil engineer; (3) structural engineer; (4) electrical engineer; (5) finance manager; (6) planning manager; and (7) IT professional. A diverse cross-functional team was established to ensure that all the strategic SWOT factors associated with the PMIS would be addressed prior to implementation.

8.2 Step 1: SWOT Factors

The first meeting was convened to address the strategic factors associated with the proposed PMIS. Firstly, the group collated a list of relevant external opportunity and threat factors, considering the macroscopic level of the construction industry and the microscopic level of construction projects. Secondly, the group examined the organisation's internal strengths and weaknesses, which may enhance or hinder the efficient and effective implementation of the proposed PMIS. A total of 28 strategic factors were collated and grouped into four categories: strengths, weaknesses, opportunities and threats.

8.3 Step 2: SWOT Analysis

In the subsequent meeting, the list of SWOT factors was analysed using the developed hybrid SWOT/AHP technique mentioned previously to establish the priority of each factor. The priorities of the factors included in the SWOT analysis were estimated by pairwise comparisons. These comparisons were undertaken by the RC using the ratio scale 1,3,5,7 and 9 developed by Saaty (1990). Computation of eigenvalues was achieved using Expert Choice (2000) AHP software to derive the relative and global (overall) priorities of factors. The whole situation is easily observed by referring to Figure 2 where cumulative scores for SWOT factors are plotted in their respective quadrants. The highlighted 10 factors represent those with the highest priorities and constitutes about 75% of the total priority of all 28 factors. Positive factors predominated (seven out of ten of the highest overall priorities represented opportunities and at present there are only three specific threats or weaknesses that could be detrimental to the new strategy). These dominant factors can be picked out to form the basis for the formulation of the PMIS diffusion strategy.

8.4 Step 3: IT/IS Diffusion Strategy 'Story Telling'

The next task of the RC was to develop a diffusion strategy that elaborates on the significant SWOT factors detailed previously. The diffusion strategy describes how the proposed project will benefit the organisation, how organisational assets and processes will be affected by the new PMIS and what changes will be necessary to take full advantage of the PMIS capabilities. The ten well-documented predictors for strategic IT/IS implementation detailed in Figure 1 were addressed when analysing these benefits, processes and changes required. This is in order to facilitate IT implementation and to encourage the uptake of IT by departments and staff within the organisation. Firstly, the perceived benefits to the organisation derived from the PMIS were identified against predictors such as 1) relevance to the organisation, 2) project environment, and 3) user utility. These are listed as follows:

- Reduced travel to the 120 sites to gather information. This is achieved by the PMIS storing electronic copies of site information ie. digital photographs, site visit reports, surveys etc;
- Electronic storage of site information reduces data re-entry, administrative costs and provides a more efficient document control and reporting system;
- All employees will have access to e-mail, Intranet and Internet. This access will be available to site office staff using fixed personal computers and field staff using remote laptops and mobile phone networking.
- Utilisation of traditional communication means such as fax, telephone, courier, mail etc. will be reduced leading to lower project overheads;
- Client satisfaction is more likely to increase due to faster reporting processes, easier access to information and instantaneous document/drawing transmittal; and

Secondly, organisational assets and processes that will be affected by the new PMIS were identified in order to 1) assign responsibilities, 2) increase user involvement, and 3) better utilise available resources as follows:

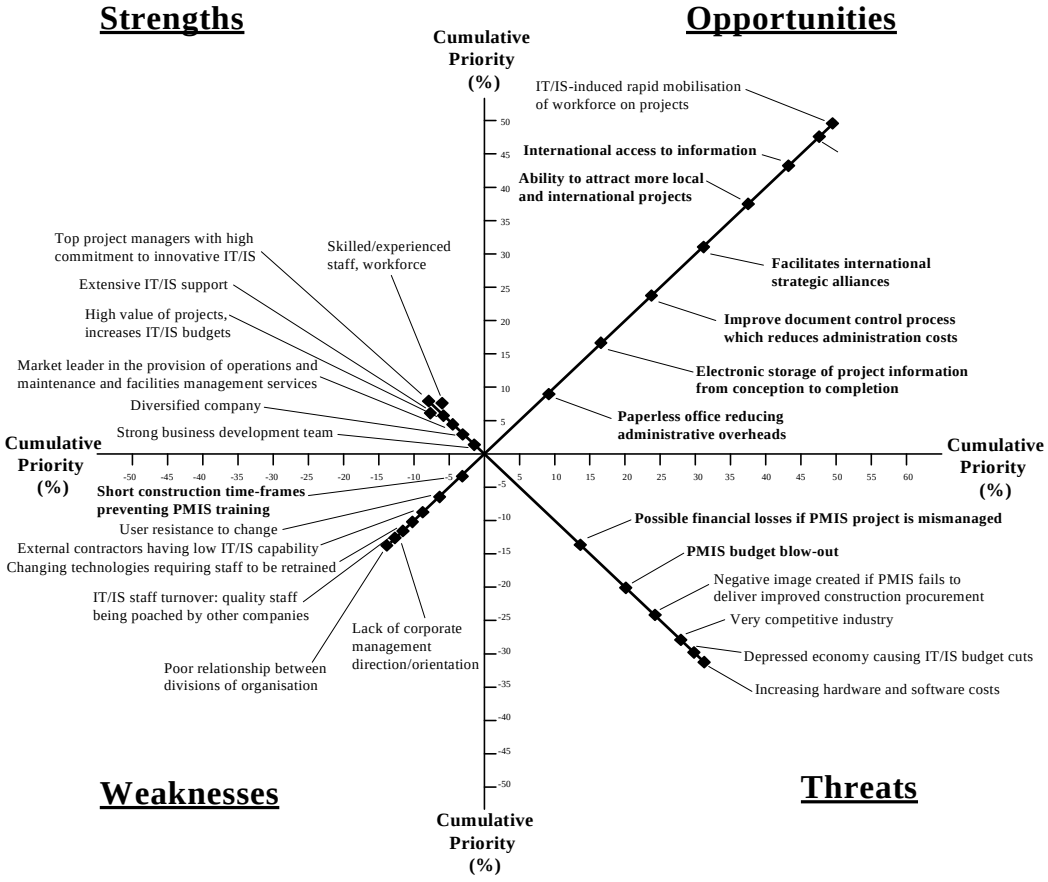

Figure 2: Graphical Representations of the Results of Pairwise Comparisons of SWOT Groups and Factors

- Improved field environment through the provision of remote networked access to the PMIS;
- Digital cameras and palm top computers supplied to field staff gathering site information;
- Reduced reliance on paper-based information to ensure maximum utilisation of PMIS;
- Field staff will be responsible for the storage and retrieval of all project information via the PMIS;
- Progress claims will be e-mailed directly to the client to aid quick approval; and

Lastly, the required changes to take full advantage of the PMIS were highlighted with the view to ensure 1) management support, 2) minimal resistance, and maximum user understanding of the PMIS functional and technical features. These are as follows:

- Awareness sessions to familiarise project staff of the PMIS and its benefits in an attempt to reduce resistance from the potential users;
- The project team will be given specific tasks and responsibilities to eliminate multiple data entry;
- A full-time IT professional will be dedicated to this contract to manage IT/IS hardware and software;
- A dedicated IT/IS training program to ensure maximum utilisation of PMIS. Users will need to be familiar with all PMIS modules, remote networking and word processing packages prior to project commencement.

The above mentioned diffusion strategy was instrumental in mitigating the effects of the perceived threats to the successful PMIS implementation, particularly the significant threat of financial losses if the PMIS is mismanaged.

8.5 Step 4: Operational Strategy

The diffusion strategy mentioned above was then codified in terms sufficiently clear to render them formally operational. The diffusion strategy was analysed in terms of functions, hierarchies and responsibilities, as well as in terms of the technical architecture required for the building of the PMIS and associated tools. The RC determined

that the best way to detail the operational strategy was to align the construction project implementation strategy with the PMIS implementation strategy, see Figure 3. The four components of the construction project implementation strategy include (1) project conception, (2) planning, (3) design, and (4) construction and commissioning. Assigned to each of these components was an operational strategy for the PMIS detailing the required business functions, hierarchies and technical architecture mentioned previously (see Figure 3).

8.6 Step 5: Implementation Strategy 'Action Plans'

In a subsequent meeting, the RC developed action plans for each function or element of the operational strategy. After defining the implementation requirements, the RC began to elaborate on the objectives, timing, cost, resources and coordination dimensions of these functions. For each function detailed in **Figure 3**, see highlighted function labelled 'installation and networking', for example, an action plan with the five dimensions mentioned previously was developed. In addition to well-documented action plans, the RC developed coping strategies for envisaged risk factors in an attempt to reduce the process and outcome gap. The RC identified a number of risk factors that could be detrimental to the efficient and effective implementation of the PMIS. The developed action plans and mitigation of risk factors through coping strategies has ensured that the realised processes and outcomes are those intended by the RC. Due to the size constraints of this paper the case study action plans could not be detailed herein.

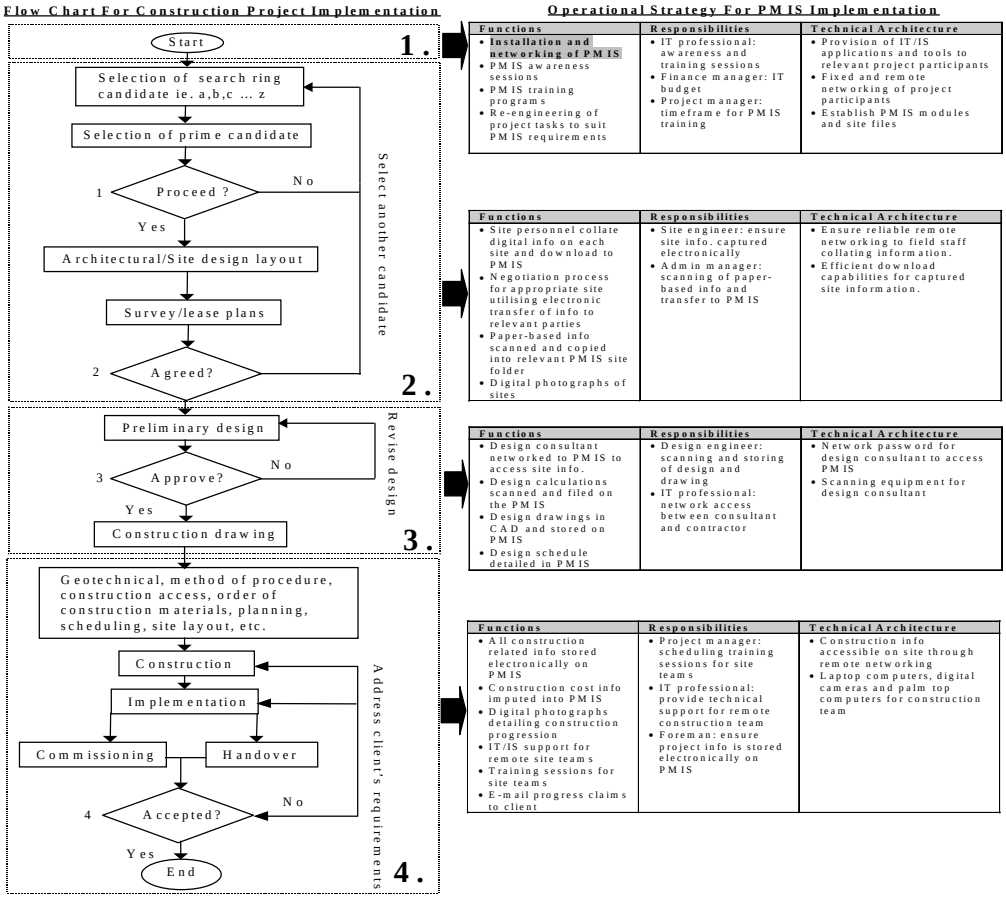

Figure 3: Operational Strategy for Proposed PMIS

8.7 Step 6: Monitoring Plan

Finally, the RC decided to implement a performance-monitoring plan to continually evaluate the implementation and usage of the PMIS. A limited number of IT/IS performance indicators and associated measures were selected to serve this purpose. Measurement collection tools were also detailed for each measure developed by the RC. Data collection would be undertaken continually throughout the construction period and summarised at the end of the project. Since this was the first project using the PMIS, the measurement results obtained on this project will serve as a benchmark to evaluate any IT/IS-induced performance improvement on future projects.

9. CONCLUSION

The proposed strategic IT/IS implementation framework suggested herein serves to accelerate the rate at which changes in people, tasks and organisational structure will take place. In so doing, the gap between the rates at which the technology and the other three components change will be reduced or eliminated. The case study with a multi-national organisation reports on the application of the proposed framework to facilitate strategic implementation of a PMIS for the project management of telecommunications infrastructure in the South-East of Queensland, Australia.

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