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Web-Based Inception Decision Support System for Healthcare Construction Projects

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ABSTRACT

Project appraisal or feasibility study is an important stage in any project life cycle. For a healthcare project, developing Space-Programming *with its preliminary capital cost estimate is considered the most important task in its appraisal stage. Many options with a huge amount of information must be generated and analysed in a very short period. Due to the high degree of repetition of healthcare projects, the same types of risk factors are likely to occur in similar future projects. Assessing these risks and their impact on cost parameters, will lead to more accurate capital cost estimating for a facility. This paper describes a* Decision Support System *(DSS) conceptual proposal for the inception stage of healthcare project on the World Wide Web. The system's main objectives focus on assisting decision-makers in the United Arab Emirates in reflecting risk factors associated with healthcare projects in their decisions while approving budgets. In addition, the system will assist in examining different space program alternatives with their associated capital budgets. The Internet is utilized as a mechanism for communicating and updating project data and cost information. This research will focus on highlighting the relation between the intentions and objectives of the system and the proposed strategy for its design and construction.*

1. INTRODUCTION

Construction cost estimating is considered the most essential task in the budget development of any project life cycle. However, it is carried out under conditions of uncertainty. Vital decisions will be taken based on that estimate in different project phases. Traditional cost estimating methods are unsatisfactory aids to decision making due to their lack of accuracy especially in feasibility or appraisal stages. Optimistic scenarios with incomplete information about the project objectives, its scope of work and its associated risks, lead to a low estimate of costs and a high estimate of benefits. For a healthcare project, developing *Space Programming* with its preliminary capital cost estimate is considered the most momentous task in its appraisal stage. A successful operational facility depends heavily on the initial architectural *Space-Programming* stage preceding its design. Many options with a very large amount of information must be generated and analysed in a very short period.

From the viewpoint of risk management, the appraisal phase is the most crucial one. It is the phase with which the greatest degree of uncertainty about the future is associated. During this phase, the key decision regarding the choice of options is made (Smith 1999). Due to the high degree of repetition of healthcare projects, the same types of risk factors are likely to occur in similar future projects. By assessing these factors and their impact on the project cost parameters, a more accurate capital cost estimate for a facility can be reached. Furthermore, the documentation and identification of these factors will assist in reducing risks to an acceptable level for the public or private investor.

In the Arabian Gulf area, where rapid construction cycle is taking place, The United Arab Emirates (UAE) is considered one of the leading countries, developing its infrastructure in many fields. The percentage of the national income spent on construction in the UAE has increased tremendously since the discovery of oil. However, many UAE public projects fail to achieve their financial goals. Statistics show a big variation between feasibility estimate and contract price (Al Zarooni, S., and Abdou, A., 2000). These variations could be understood knowing that feasibility estimates in the government agencies are usually budgeted using a cost per square foot ($/GSF) basis, regardless of the nature of projects and their associated risks as well as the construction complexity of each building type. Two major factors combine to create the situation where UAE public healthcare projects suffer from cost and time overruns. Firstly, the consequential changes arising from insufficient scope definitions and secondly, the lack of appropriate communication and coordination between the government bodies involved during the healthcare project.

2. RESEARCH OBJECTIVES

The aim of the study described in this paper is to develop a ***Web-Based Inception Decision Support System*** for UAE Public Healthcare construction projects. Furthermore, this system should adopt a "risk assessment approach" to the decision making process. The system's main objective focuses on assisting decision-makers by reflecting risk factors associated with budget approval decisions on healthcare projects. This will provide them with confidence that the budget is sufficient for construction of a facility that provides the required quality of service. It will also assist by allowing the rapid examination of different space program alternatives and their associated capital budgets. The system will help local owners, developers, design professionals and construction managers for healthcare projects to produce reliable budgets and complete projects with lower costs.

The detailed research objectives can be summarized as follows:

- Identifying risk factors and uncertainties associated with space programming and facility planning which could result in cost variation between the inception stage cost estimate and the tender price of the healthcare facility. These factors will be classified and weighted in order to develop a risk breakdown structure that will be accommodated in the proposed computer system.
- Developing a space-programming framework for the UAE general hospital building type. The different spaces and functional elements will be classified and organized, forming a *Space Breakdown Structure* (SBS) to be accommodated in the proposed computer system.
- Developing a cost database updating mechanism that is responsible for updating the internal database management system. Future cost and tender data from bidders including contractors and equipment suppliers will be the vehicle for that mechanism.

3. RELATED PREVIOUS WORK

Information modelling to support inception and early design of *Large Scale Engineering* (LSE) projects (power and process plants, civil engineering, healthcare facilities, factories or infrastructure works) has not yet been reported much in the literature (F. Tolman et al., 1999). The inception support for LSE projects was the subject of a research project that started 1995 between TU-Delft Faculty of Civil Engineering and TNO *Building Construction Research*. Several knowledge-base prototypes were proposed and developed. Among them, the *Hospital Inception Support System* was developed by Schevers in 1999. The aim of this system was to support the feasibility study stage. It allowed users to make in-depth studies of more alternatives in a shorter period. The required function, their total volume and floor space etc. are included. Useful information could be then predicted automatically, for example: erection costs, construction time and energy usage. However, the system focused on knowledge management within a company by incorporating company-specific knowledge and know-how about the end user's view for a certain building type. As such, it was used in order to share and document knowledge between co-workers. It will be hard to use the system from a client point of view. In addition, architectural space programming for a hospital facility with its associated risks was not covered in that system. Other work, like that at Carnegie Mellon University, USA (SEED, 1999) intended to provide *Architectural Design* support for a recurring building type without emphasising much its cost parameters.

Potential applications of the Internet in the construction industry have generated many recent research projects. This new infrastructure for communication creates a unique platform for Decision Support Systems (DSS). The benefits of this platform include greater accessibility, more efficient distribution, more effective administration and a greater degree of flexibility across a user's individual operator platform (Molenaar, K. et al., 2001).

The first wave of web-based systems facilitated document management and collaboration activities among project participants in order to save time, communication cost and paper work. Med (1997) discussed the possible use of Intranets in the construction process. He suggested a project web site to include a library of integrated management information that could enhance the performance of the project team. That information included updated project schedules, meeting minutes, change orders, updated drawings, etc. He also suggested transfer of different files to Hyper Text Mark-up (HTML) Language format for ease of viewing and updating. Tam (1999) investigated the potential of the internet to facilitate information transfer between construction project participants in Hong Kong. He developed a system called "Total Information Transfer System". It comprises document management and collaboration functions such as data exchange and remote login, white boarding chat, video cam, email system and search engine. Abdou (2000) reviewed more than twenty new, web-based, commercial systems for project and construction management. He concluded that, by providing better document management, collaborative activities and online business process models along with E-commerce facilities, Web-Based tools have the ability to reduce time and cost for the construction industry.

Recently, research has investigated the web potentials for decision support in project control and feasibility process management. Abudayyeh et al., (2001) suggested the use of an Intranet-based project management system, focusing on cost control as a mechanism for improving the quality and timeliness of information. They developed a Web-based cost control system, where data and cost information are centrally stored and processed by a database management system. The authors highlighted the potential benefits of using web technology for project control. They mentioned the instant, automated, online reports that could be produced up-to-the-minute and on-demand that will lead to improvements in decision-making processes. Al-Tabtabi (2001) suggested a web-based information control system for the project appraisal stage. He highlighted the problem of public projects in Kuwait suffering from insufficient scope definition due to lack of information and slow processes in the pre-design phase. By utilizing the Internet as a vehicle for communication, the system's main objective was to support pre-design phase processes and information management.

For healthcare buildings, *Architronix Software* developed a decision support system for project appraisal, **arcSP**, which is a web-based commercial tool (arcSP 2002). The focus of this system was to perform space programming for a healthcare facility. This was aimed at providing a detailed tally of space and capital cost of a facility before the design stage commenced. It used demand workload and utilization factors for specific components, building standards and codes for performing these tasks. The system has an easy and well-organized user interface. However, its cost estimating technique was based on a cost-per-square-foot value, which had to be entered by the user for their individual projects. Although the system provided a good space programming analysis and the initial cost provided was useful in comparing alternatives, its reliability, as an accurate cost-estimating tool was limited. Using cost-per-square-foot for pricing healthcare facilities will not be accurate due to the variation in cost for each space function of a facility (for example, the cost of an operating theatre area is not the same as the outpatient department). In addition, risks associated with the space programming factors and their impacts on cost parameters were not taken into account.

4. THE WEB-BASED HEALTHCARE INCEPTION DECISION SUPPORT SYSTEM (HIDSS): DESCRIPTION

Focusing on assisting decision-makers in the appraisal stage of a healthcare facility, a decision support system has been designed where data and information are centrally stored and processed on a Web server. The targeted user group for this system is UAE government decision-makers. In addition, owners, developers and design professionals can use the system as well. The system can be described as follows:

1.1. Decision Making Processes Model for User Interface:

The system is an interactive tool that will assist the user in the processes of space programming for a facility, studying cost alternatives and selecting associated risk factors. The result will be a report including: facility spaces, areas and its initial cost probability. These main processes are shown in Fig. 1.

***Fig. 1**: Decision Making Processes Model for User Interface*

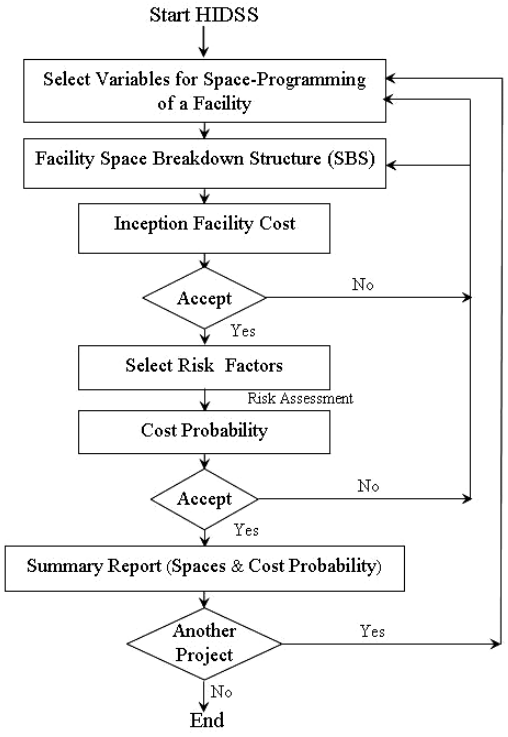
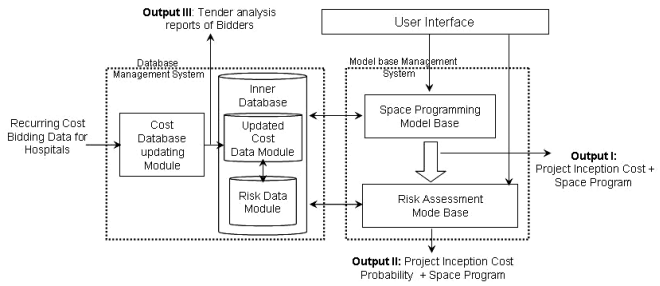


***Fig. 2**: Healthcare Inception Decision Support System (HIDSS) - Basic System Architecture*



1.2. Basic System Architecture:

All execution and computational processes occur on the DSS server. Data are exchanged between users and the DSS server via HTML pages and forms. The system's basic architecture consists of: (a) The user interface. (b) A model database that contains space programming and risk assessment models. (c) A data base management system that contains a real-time cost database that is updated regularly by a web-based updating module using the recurring cost bidding process for healthcare projects. The Basic system architecture is shown in Fig. 2.

1.3. System Components:

detailed system architecture and components are shown in Fig. 3. It can be described as follows:

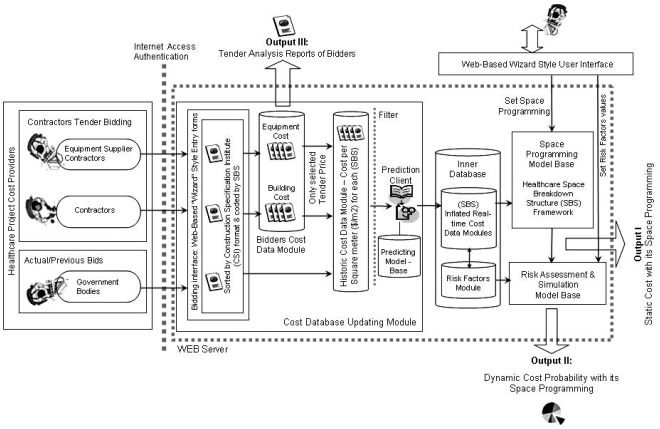
1.3.1. The User Interface

User interaction and data input will be via a web browser pages using HTML and ASP languages. A login password is required for the intranet access. A web-based "wizard" style interface will guide users throughout the appraisal processes, as detailed in Fig. 1.

1.3.2. Model Base Management System

"Modeling is an integral part of any traditional DSS that supports individuals making semi-structured decisions. Mathematical models are used for the structured part, leaving the decision maker to exercise judgment in handling the unstructured part. Thus, the purpose of modeling is not just to get an answer, but also to develop sharper insights into, and understanding of, the problem itself, by examining various facets of it, and by exploring alternative ways of looking at the problem" (Bodily, 1985, PP.5-7).

***Fig. 3**: Detailed System Architecture*



The proposed system has two main models:

***1.3.2.1. Space Programming Model*:** In this part, the variables affecting facility space programming will be modelled. The spaces will be categorized and structured using the *Space Breakdown Structure* (SBS), which will be connected to the cost database.

***1.3.2.2. Risk Assessment & Simulation Model*:** Different risk factors affecting the space programming or the overall facility appraisal cost will be categorized and modelled. A Monte-Carlo simulation process will be accommodated as well.

1.3.3. Database Management System Schema

The data management component reflects a fundamental aspect of any DSS. Most decision support features involve access to, or manipulation of, data (Ariav & Ginzberg, 1985). The database schema proposed for this system is described in this section.

1.3.3.1. Cost Database Updating Module: a mechanism for using the recurring bidding process in the tender stage of a healthcare project as a source of a reliable, in-house cost index is proposed. The main parts are:

- **Bidder Interface**: a password is needed for invited bidders to access the web-based, wizard bidding pages where they submit their best prices for the facility during its tender stage. Online bills of quantities, using the Construction Specification Institute (CSI) format, will be coded by the Space Breakdown structure (SBS).
- **Bidders Cost Data Module:** the different bids will be stored in this module. Reports can be generated to assist clients' decision-makers in tender selection.
- **Historic Cost Data Module**: only approved tenders will be used to update this module. Along with the available previous tender prices from old projects, this module will contain a dated-stamped cost-per-square-meter ($/m2) values for each SBS element.
- **Prediction Client**: containing a mathematical Model/formula with required updating period interval. The *Prediction Client* will inflate the historic, unit costs for each SBS element.

***1.3.3.2. Internal Database Module*:** in this module, the inflated real-time cost data for each SBS element will be stored with a direct connection to the Space Programming Model base. It will also contain a module for risk factors and their potential cost impacts

5. SYSTEM CONSTRUCTION AND IMPLEMENTATION

A conceptual design proposal for Web-Based Healthcare Inception Decision Support System (HIDSS) has been presented in this paper. The following stages will be the construction and implementation of the system which will be described in future publications. In these stages, the general hospital *Space Breakdown Structure* (SBS) as well as its associated risk factors will be modelled in order to be accommodated in the model database. The database management system will then be implemented using MS Access. After that, the user interface will be developed and linked with the database management system to the Web, using HTML and ASP languages. A proper web Access Authentication will be then implemented.

In order to implement this system, hardware and software facilities are needed. These requirements include: a server computer with a windows or NT environment and IIS web server software. In addition, client terminals at the government organization with Internet access and web browsers are also needed.

6. CONCLUSION

The proposed web-based system, described in this paper, focuses on incorporating a risk assessment approach in the architectural space programming process in order to obtain a more precise inception cost estimate of healthcare facilities. The system will assist the decision-maker in examining different architectural space program alternatives and their associated capital budgets, in a short period. It will also assist in

developing a clear scope of work in terms of architectural space programming for the proposed facility prior to its design stage. The Internet is utilized as a mechanism for communicating and updating project cost data and information. By using historic cost data as a starting point, and adding to this through the recurring bidding process during the tender stage of subsequent projects, a reliable, in-house cost index will be generated automatically. By providing proper security measures, several benefits could be achieved from using the web technology, including: greater accessibility to government users, more effective administration, better processes timeliness and paper work elimination. As a result of these improvements, the analysis and decision making processes will be more effective.

REFERENCES

Abudayyeh, O., Temel, B., Al-Tabtabai, H., and Hurley (2001) "An Intranet-Based Cost Control System", Advances in Engineering Software, No. 32, Page 87-94

Abdou, A., 2000, "Collaborative Management Tools in the Information Technology era", Project Management Institute (PMI-AGC), 7th Annual Conference, Bahrain, February

Al-Tabtabi, H. (2001) "Web-Based Information System for the Pre-design Phase", Project Management Institute (PMI-AGC), 8th Annual Conference, Bahrain, May

Al Zarooni, S., and Abdou, A. (2000) "Risk Management in Predesign stage and its Potential Benefits for UAE Public Projects", Proc. of the 28th World Congress on Housing, Abu Dhabi, UAE, April. Page 109-118.

ArcSP (2002) http://www.arcsp.com/portal/simpleIndex.asp

Ariav, G. & Ginzberg, M. (1985) "DSS Design: A Systematic View of Decision Support", Communications of the ACM, Vol. 28, No.10, page1045-1052

Bodily, S. (1985) "Modern Decision Making: A Guide to Modelling with Decision Support Systems." New York, McGraw-Hill.

Mead SP. (1997) "Project – Specific Intranets for Construction Teams", Project Management Journal, Vol. 28 No. 3.

Molenaar, K.R. and Songer A. S. (2001) "Web-Based Decision Support Systems: Case Study in Project Delivery", Journal of Computing in Civil Engineering, Vol.15, No. 4, Page 259-267.

SEED, 1999, http://seed.edrc.emu.edu/OverView.html

Smith N. J. (1999) "Managing Risk in Construction Projects". Blackwell Ltd.

Schevers, H. (1999) "Conceptual Design Support for Technical Buildings", TU-Delft, Master thesis

Tam CM. (1999) "Use of Internet to Enhance Construction Communication: Total Information Transfer System", International Journal of Project Management, Vol. 17 No. 2

Tolman. F.P., Ozsariyildiz S. and Schevers, H. (1999) "Information Modeling to Support Inception and Early Conceptual Design of Large-Scale Engineering Projects", International Journal of Construction Information Technology, Volume 7, No. 2, Page 73-83.