AN EXPLORATION OF THE POTENTIAL USE OF A WEB-BASED PROJECT MANAGEMENT SYSTEM TO MANAGE CONSTRUCTION PROJECTS BY ROYAL COMMISSION OF JUBAIL

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The invention of the Internet based technologies and systems has facilitated collaborative working environment in the construction industry by generating new opportunities for collaboration, coordination and information exchange among firms that work on construction projects. Web-based project management systems (WPMS’S) allow project team members to communicate and exchange project information in a fast, cost-effective, and efficient manner. It enhances project communication, documentation and control, and overturns the way in which a construction project team traditionally conducts business. This paper investigates the potential use of WPMS systems for managing construction projects by Royal Commission for Jubail (RCJ). A questionnaire survey followed by interviews were conducted on RCJ project management teams to find out their views about present management problems and how far would WPMS help to sort it out. The researchers discuss how present project management methods and processes should be changed to – on one hand- improve the whole project management system and – on the other hand- to grasp potential benefits of the proposed use of WBMS and avoid possible barriers that would affect the implementation of WPMS.

Key Words: Web-based project management system, management processes, construction industry, Extranet

1. INTRODUCTION AND BACKGROUND

Management of construction projects concept involves avoiding problems, tackling new ground, managing and communicating a group of people and trying to achieve very clear objectives quickly and efficiently by using management technique and process\[1\]. The management objectives usually refer to scope, quality, time, cost or what is so called golden triangle. The refinement of the objectives results the inclusion of other objectives such as sustainability, and project team and has a participants' satisfaction and health and safety. As the complexity, size, volume of projects and the requirements of stakeholders has increased substantially during the next half of the 20th century, it is found that traditional management systems can not cope with and have a number of shortcomings. The invention of the Internet, wireless and mobile systems has motivated the creation of advanced electronic management systems that helped construction firms to more effectively manage the increasing complexity in construction projects.

The royal Commission of Jubail represents a special case. It manages an increasing number of projects of various sizes. With the increasing number
of projects at Royal Commission for Jubail and expected changes by the strategic plan and the orientation of Royal Commission to become a center for management of the economic cities in Saudi Arabia, also because some of these projects are geographically far away from the main headquarter, the need of finding serious solutions to use of advanced systems to manage the current and future projects. The pilot study highlighted some frequent problems that affect the project construction and these are related to communications, coordination, collaboration and exchange of information. Such type of problems can be effectively sorted out using a web based project management system. However, it seems that the problem is not with purchasing a management system. Ahuja (1994) pointed out that with increasing availability of a broad range of construction project management applications, organizations are generally disoriented and uncertain with respect to which applications and tools are best suited to their business goals. Furthermore, with project management systems becoming more and more complex and encompassing sophisticated practices for better management and control, selection of such tools has become increasingly difficult[2].

This research examines whether the use of Web based project management systems WBMS would help the Royal Commission of Jubail supervision team to manage an increasing number of projects, enhance communications and provide the construction team including the contractor with the immediate support and improve the project performance. It aims at helping RCJ to select the right system. A survey was undertaken on Royal Commission of Jubail supervisors and engineers to find out their views regarding the potential use of WBMS and type of adjustment to the present management system to enable successful implementation and use of WBMS.

2. SHORTCOMINGS OF TRADITIONAL CONSTRUCTION PROJECT MANAGEMENT SYSTEMS STUDY

Various types of information are required by construction team and these would include; request of information such as reports, material management, equipment management, cost management, schedule and means and methods, jobsite record keeping, submittals, safety and quality control and quality assurance[3]. These communication activities can not undertaken effectively and efficiently using traditional communications and information management systems as it has shortcomings and incapable to fulfill project duties[4]. One of the shortcomings that it provides limited access to information which is considered as one of the key barriers to project management practices[5,6]. Chan et al mentioned that the success of a construction project is affected by a number of factors and among these is the project management actions and project procedures that include: communication system, control mechanism, feedback capabilities, planning effort, developing an appropriate organization structure, implementing an effective safety program, implementing an effective quality assurance program, control of sub-contractors’ works and overall managerial actions[7]. Biggs also lists communication as the root cause of most project failures[8]. Recent studies by Stichiting Bouw Research centre in the Netherlands indicates that 6 to 7% of the contract expenses can be allocated as expenses due to failures[9]. A lot of these failures are caused by an inadequate organization/ management of the construction process, e.g. a weak coordination of processes and uncertainty about available information[10].

3. REVIEW OF THE USE OF ELECTRONIC SYSTEMS IN MANAGEMENT OF CONSTRUCTION PROJECTS

The above mentioned traditional construction project communications and information management problems would be avoided if efficient management system and tools are used. WBMS are electronic communications and management systems that use wireless, Internet based or mobile tools and networks to facilitate communications and management of projects. These systems have a potentiality to help the project team members to effectively manage projects. Today; many types of wired, wireless systems and services are available and can be interlinked to form the end-linked network for communication and information transfer. Web based services can be categorized into four categories: Information and Enterprise portals, electronic marketplaces and web-based project management system[11].

Thus these systems can be used by construction project team to improve communications, share information and solve problems that help manage time and cost[12]. These systems can track the projects’ progress and account for their budget long before problems develop. Biggs notes that the latest web-based solutions which can be linked with email or collaborative software can reduce the incidence of people related issues and overall communication problems which lead to project failures. This would ensure the smooth flow of project work, providing accurate, speedy and updated information and sorting out constructions problems quickly. Davidson & Moshini mentioned that the cost of construction can be reduced by 25% through the efficient transfer of information between the construction teams [13, 14]. Researchers identified a number of benefits from using WPMS technology that aim to improve project management methods, these benefits include the following[11,15],

a) Enhancement of productivity of face to face meetings between project participants by providing
by providing timely and concise information in order to make more effective decisions
b) Reduction in project delays
c) Heightened all parties awareness of the project issues, and;
d) Ease of access and retrieval of project information

Other advantages include: avoiding delays because of the arrival of updated drawings documents, reducing visits to site and traveling time to meeting, avoiding drawings mistakes, reducing time and money spent on disputes, sharing and exchanging project information, automate repetitive routine processes and elimination of paper reports[11].

Nitithamyong and Skibniewski[16,17] suggested that benefits of using WPMS can be categorized into four main areas. These categories are:

a) Cost reduction and time saving.
b) Enhancement of communications and collaboration
c) Improvement of productivity and partnership
d) Supporting e-commerce and customer.

It is however found that advanced electronic systems have some shortcomings meanwhile their benefits are not fully perceived by the construction industry. Communications and information systems are said to be time consuming, error inclined and highly dependent on human initiative and expertise. There are some problems that might occur when implementing electronic information technology (IT) into the business and may incur extra cost and limit the potential benefits and these are:

- The road to learn how to properly use IT is rough.
- It is difficult for the staff to adapt to new procedures.
- IT applications have various critical masses.
- The effects might be indirect.
- The tangible are often short-lived.
- IT benefits cannot merely be measured in financial profits.
- IT is merely a tool that can be used either rightly or wrongly, but on its own, it does not do anything[24].

Despite the adoption of electronic management systems by construction firms, current construction project management practices are found often isolated and are concerned with managing problems related to individual stages of the projects[11]. Very powerful software packages were produced for the construction industry, meanwhile they have been deployed on “adhoc” basis by construction firms and this has resulted in improvements at their local level of implementation, such as planning, estimating, design, etc but have had added limited benefits at the project level[25]. Management tools are being implemented, but are principally used for visualization and not for mathematical process modeling towards project support and optimization. If any experiential knowledge and real-time data is available, it is not integrated with other systems forcing multiple entries of data into alternate scenario planning, which might be redundant and/or inaccurate. Optimization techniques are not implemented during conceptual planning and design processes[26]. Nitithamyong & Skibniewski investigated how to make the use of WBPMS successful[16]. The study found barriers that still affect the implementation of WPMS by construction companies. The researchers mentioned that companies are still wait for an (professional or efficient) approach to use WPMS and request more definitive cost and benefit data to decide whether to use WPMS or not. Others such as Yang et al., Nitithamyong and Skibniewski, Walker et al., Vileneuve et al., Chan et al. pointed out other disadvantages such as direct and indirect cost, staff training, user resistance, system reliability and security issue[4,16,21,18,7]. Some organizations request more definitive cost and benefit data to decide whether to use WPMS or not. Weipert et al discussed the technical side as they set an emphasis on system design, training etc[19]. They set a list of “best practice guidelines” that are critical in helping ensure successful implementation of ICT tools and/or ICPM systems on geographically dispersed civil and building construction projects. These recommendations include:

- Use of one system only by all Project participants
- System compatibility.
- Ease of data entry.
- Fully-resourced implementation.
- End-user – prime focus.
- User v. quality and accuracy.
- Trust
- Designed for the construction industry by the construction industry.
- Training
- Commitment.
- IT driver
- Legal issues.

4. RESEARCH METHODOLOGY AND OBJECTIVES

The examination the archive of three completed projects revealed a number of problems that affected the progress of these projects during the projects periods. The most frequent problems were:

- Slow response from both sides i.e. the contractor and RCJ regarding technical issues (57 times)
- Long time that is spent to review and submit as-Built drawing (21 times)
- As-Built drawings do not reflect what had been built particularly regarding the services’ such as sewage and water installations (11 times)
- Shortage of manpower (8 times)
- Coordination problems between the contractor and various RCJ departments (7 times)
- The slow recruitment process carried out by the contractor to employ sub contractors and key project personnel which delay to the RCJ
approval to the employment (6 times)
- Slow materials procurement process (5 times)
- Late submission of progress report (5 times)
- Miscommunication problems by both sides (5 times)

It is obvious there are communications, co-ordination and management problems and some of these are very frequent and significant. This motivated the present research to find out whether WPMS system is capable to overcome these problems or some at least. Hence, the objectives of this research are:
- To investigate the features and tools of the present project management system at RCJ;
- To investigate possible hindrance, or barriers that would affect the implementation of WPMS; and
- To help RCJ to choose the optimum WPMS system.

The total number of construction project management staff of RCJ & SABCO (i.e. Saudi Arabian Bechtel Company; the RCJ consultants) is one hundred and thirty one and this includes senior managers, and engineers, construction projects' managers and supervisors. The questionnaire was sent randomly to fifty of them who have the good experience and will definitely respond back. Thirty three out of the fifty responded back, twenty from Bechtel and thirteen from RCJ. The response rate is around 66% out of the sample and 25% of the whole population. The results were analyzed using simple analysis techniques.

5. RESULTS OF THE MAIN SURVEY

Respondents were asked about the construction project management system that they use at present. The study found that 10% use Custom made software applications developed by external agencies, 16% use custom made software applications developed by internal IT and software department, 44% use Commercial off-the-shelf software applications whereas 32% do not use any project management system. Respondents stated that most efficient communication systems - ranked according to its efficiency rate- are: telephone, e-mail, hard copy (letters) and Fax whereas the most efficient management systems are: Primavera, MS Project, automated collaboration software tools (EDMS). 35% of them said EDMS is not applicable, 25% said that Primavera is not applicable and 55% said Timberline software is not applicable.

Respondents said that the more frequent tool used is the telephone and email to contact other RC departments and the telephone and other types of communication tools to contact contractors (table 1). However, table (1) shows there is less frequent communications with services agencies. Hubbard highlighted factors that affect the success of construction projects and respondents were asked which of these factors would affect the management of RCJ projects[27]. Respondents mentioned the following factors mostly affect the management of construction projects and these are ranked according to its importance (from more to less):
- Monitoring and Control mechanisms
- Planning effort
- Well defined scope & Budget
- Adequate communication tools
- Level of contractor's experience regarding site management
- Level of contractor's experience regarding project management
- Speed of information flow between RCJ and the contractor
- Level of project management team’s skills.

<table>
<thead>
<tr>
<th>Communicate With</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other R.C Dept</td>
</tr>
<tr>
<td>Contractors</td>
</tr>
<tr>
<td>Services agencies (SEC, Marafiq, STC)</td>
</tr>
<tr>
<td>Others</td>
</tr>
<tr>
<td>Averaged frequency of the daily use of communication tools</td>
</tr>
<tr>
<td>Telephone</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>2.2</td>
</tr>
<tr>
<td>1.23</td>
</tr>
<tr>
<td>1.67</td>
</tr>
</tbody>
</table>

Note: scale: 1=less than 5 times, 2= 6 to 11 times, 3= more than 11 times

Respondents said the following features of an electronic project management system are very significant when considering to buy/ not to buy the system and these ranked according to its effectiveness (from more to less):
- Work breakdown, planning, scheduling and monitoring
An Exploration of the potential use of a Web-based project management system to manage construction projects ......

- Submittals, management, approval and review cycles
- Periodic reporting cycles, statistics, timelines, progress rates
- Change orders, managing, documenting and collaboration
- Project budgets, financial analysis, monitoring and cash flow
- Contract administration, finance and records
- Resource management, forecasting, availability and utilization
- Purchase orders, tracking and related documentation management (Table 1, Appendix A)

Respondents said that the following factors affect heavily the decision to select a WPMS system and these ranked according to its effectiveness from more to less:
- Communication and networking capabilities of the system
- Data transfer capabilities to/from other computers and devices
- Hardware resource requirements of the application
- Business data security concerns
- The system's compatibility with other office solutions applications
- Ease-of-Use and user friendly interfaces of the system

Respondents said that the following features of an electronic project management system would enhance highly the electronic project management performance by RCJ and these are ranked from more to less (Table 2):
- Meeting staff expectations/demand for easier/better software's
- Facilitating feedback from clients/partners/subcontractors
- Meet clients expectations/demands/preferences

<table>
<thead>
<tr>
<th>Software Features would enhance the electronic project management performance by RCJ</th>
<th>Level of enhancement (Mean value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting staff expectations/demand for easier/better software's</td>
<td>0.97</td>
</tr>
<tr>
<td>Facilitating feedback from clients/partners/subcontractors</td>
<td>0.94</td>
</tr>
<tr>
<td>Meeting clients expectations/demands/preferences</td>
<td>0.88</td>
</tr>
<tr>
<td>Generic drives for better business process practices</td>
<td>0.81</td>
</tr>
<tr>
<td>Compliance with latest/new quality assurance programs</td>
<td>0.8</td>
</tr>
<tr>
<td>Enabling Staff multi-tasking and flexible work distribution</td>
<td>0.75</td>
</tr>
<tr>
<td>Low cost of the technology</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Note: Scale: -2 very little, 2 very much

Respondents said that the following barriers would highly hinder the implementation and use of WBMS in RCJ (arranged from more to less):
- Staff resistance to change the work methodology and processes
- Low level of IT infrastructure of the organization and other parties
- Low computing proficiency levels of senior management & staff
- Major investment without guarantee of success and/or returns
- Preference of old-style paper-based/existing management protocols (Table 2 Appendix A)

6. INTERVIEWS RESULTS

Interviewees mentioned some advantages and disadvantages of the existing electronic management systems. RCJ uses (Info Work) system to manage documents and drawings. However, the present system has one main disadvantage as it can be used internally only and can not be used by contractors or any other external parties. All the documentation and archiving at the moment is a hard copy one but they try to formalize things now through info works system all way through. Usually the communications with R.C management are through conversations and meetings. The meetings and telephone conversations are effective to explain the query better and they followed up by an e-mail that outlines what was discussed. Technical Query (T.Q) system in RCJ is not very efficient because office work is done mostly manually. However, lessons-learned is used through T.Q and DCN (i.e. Design Change Notice), it feeds back to the Engineering and Design Department thus it is utilized to improve the design for new projects. The Engineering Department has the database that is designated for lessons-learned.

They also pointed out some barriers to the implementation of the WPMS and these are:

- The new electronic management system would require a high quality infrastructure capable to run the system. These systems need the Internet 24/7 so if there is any connection problem in the , the work will completely stop
- It is preferred to merge the new system with the old system to avoid any problem. It also obligatory to provide hard copies for the documents as the electronic signature is still not considered by many of the government bodies
- The dilemma is how to obligatory other parties which have business with the RCJ to use the proposed system as each company has its system
- In case of any query, the contractor should not send it by email and he should send a hard copy letter to the RCJ which would causes delay.
- The problem of information security and access rights to various members of project team.
The staff rejection to change their way of work would be an obstacle towards the use of new system.

On the other hand, they suggested adjustments to the exiting management system prior to the application of a new system. Some of these should be sorted it out immediately, whereas there is no need to immediately deal with the others. These are ranked according its' priority whereas 0 no need to sort out at present and 10 should be sorted out immediately:

a. Information technology’s Infrastructure (10)
b. The adequacy of communication tools (9)
c. Rapid transmission of information between the administration and contractors (9)
d. Task Force Skills (7)
e. Decision-making mechanisms (5)
f. Method of follow-up and control the project (4)
g. The scope of work and budget of the project (2)

They pointed out that training is required for successful implementation not only for staff but also for the contractor staff. Mixed use of communications systems and tools is required and not the solely use of WBMS. One of them said that the system should be capable to achieve the strategic targets of the RCJ and should have technical support along the period of use. Customization bit is necessary thus the new system should be flexible enough and can be customized to suite the work methodologies of RCJ. A number of capabilities should be incorporated in the new system and these include:

a. Technical queries of the contractor
b. Daily reports of the project
c. Financial invoices and bills
d. Drawings’ Review
e. It should record lessons learned so it would be useful for all departments
f. To have analysis and monitoring capabilities so it can be used to monitor and analyze the quality, time and cost of projects

t.Q on line and coordination is required on design review to get all the comments to avoid conflict between different departments. At present, RCJ is trying to convince the contractor to use the advanced management software.

7. CONCLUSION

The pilot study has highlighted a number of project management problems and particularly that related to communication and co ordination between various project parties. Some of these problems can be sorted out through the use of WPMS. Certain features are requested by RCJ and the study recommends that it should be embedded in the future WPMS. These include: ease of use, information security, flexibility of the system, database for lessons learned, analysis of project information, optimization techniques during conceptual planning and design processes, alternate scenario planning, control and monitoring, decision making, follow up mechanisms thus WPMS system would best fit RCJ requirements.

However, the study notices that some problems (see section 4) seem to be generated during other stages of the project. For instance, issues regarding expected problems (such as site personnel recruitment) in addition to unforeseen problems (such as possible shortages in manpower and slow materials’ procurement) should be studied and resolved at the relevant stages of the project (such as the planning, tendering or contracting stages). Emergency scenarios should be established at the early stages of the project to deal with unexpected issues. During the construction stage, precise daily control and follow-up procedures should be applied regarding issues such as the examination of the quality of construction work, monitoring the productivity level of site workers, and calculation of the rate of material consumption.

The research found some barriers are similar to what highlighted in the previous research such staff training, cost of the software, user resistance and system security. The study found that staff training would not enough and the contractor's staff should be trained as and the integration of WPMS with the existing management system would guarantee the success of the implementation of WPMS.

The research found some barriers are similar to what highlighted in the previous research (See also table 4).

These barriers include: staff training, cost of the software, user resistance and security of information. This research suggests that these barriers would interact in a complex way. For instance, the low IT knowledge of the senior management would hinder them from perceiving the benefits of the WPMS thus they would reject any major investment in the system. The staff who have low IT knowledge would be concern regarding the adoption of a new system as they think that they would lose their job or would be transferred to a lower job rank.

The interaction of these barriers would hinder any potential benefits and limit the applicability of these systems to RCJ.

However, some management barriers/ problems may be hard to sort out without making adjustment to the present management system and these include procedures for monitoring and control, well definition of project scope & Budget. RCJ should develop a system for choosing the right contractor for the job to avoid the lack of contractor experience which affects projects as highlighted in the previous sections.
Table 3. Potential leading factors and Barriers for Success and Failure of WPMS Implementation (adapted from[28])

<table>
<thead>
<tr>
<th>Categories</th>
<th>O’Brien 2000</th>
<th>Takamoto et al. 2003</th>
<th>Nitharmyong and Skibniewski 2006</th>
<th>The present Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government and industry</td>
<td>Legal issues—review burden under the new regime</td>
<td>Japan’s conventional culture-ambiguity does not fit the nature of IT systems, which create transparency and inclusiveness</td>
<td>The electronic signature is still not considered by many government bodies</td>
<td></td>
</tr>
<tr>
<td>Company</td>
<td>Communication density and the problem of yet another channel</td>
<td>Level of support from top Management Presence of champions</td>
<td>Preference of old style paper-based methodology. Potential integration problem of WPMS with the existing RCJ system. Legal concerns regarding date security Concerns regarding the cost of the system.</td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>Password barrier and the problems with boundary spanning</td>
<td>Different representation/ indications of project information, such as schedule chart, between the Japanese and the American style</td>
<td>Project size—type of owner Data quality and reliability Complexity related to</td>
<td></td>
</tr>
<tr>
<td>Individual</td>
<td>Resistance to change and the need for a new job description Collaborative maturity knowledge is power</td>
<td>Poor IT skills of users</td>
<td>Team attitudes towards IT Team attitudes toward PMASP-Project Management</td>
<td>Adaptation and use for ongoing critical projects. Low IT knowledge and computing proficiency levels. Staff resistance.</td>
</tr>
<tr>
<td>Technical and software product support</td>
<td>Team tools and the problem of something for everyone</td>
<td>Off-the-shelf software</td>
<td>Internet access availability Promptness of customer service response Ease of use System reliability</td>
<td>Low level of IT Infrastructure. The level of Flexibility and ease of use of the proposed system</td>
</tr>
</tbody>
</table>

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### Appendix A

<table>
<thead>
<tr>
<th>Functions of an electronic project management system</th>
<th>Level of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Breakdown, Planning, Scheduling and Monitoring</td>
<td>4</td>
</tr>
<tr>
<td>Submittals, Management, Approval and review Cycles</td>
<td>3.97</td>
</tr>
<tr>
<td>Periodic Reporting Cycles, Statistics, timelines, Progress Rates</td>
<td>3.93</td>
</tr>
<tr>
<td>Change orders, managing, documenting and collaboration</td>
<td>3.9</td>
</tr>
<tr>
<td>Project budgets, financial analysis, monitoring and cash flow</td>
<td>3.77</td>
</tr>
<tr>
<td>Contract admin, finance and records</td>
<td>3.68</td>
</tr>
<tr>
<td>Resource management, forecasting, availability and utilization</td>
<td>3.61</td>
</tr>
<tr>
<td>Purchase Orders, Tracking and Related documentation Management</td>
<td>3.61</td>
</tr>
<tr>
<td>Daily Logs, Rosters, Meeting Minutes, letters and Reports</td>
<td>3.55</td>
</tr>
<tr>
<td>Reports, Notices, Memos, Invoices and other Documentation</td>
<td>3.52</td>
</tr>
<tr>
<td>Tracking information for historical record</td>
<td>3.48</td>
</tr>
<tr>
<td>Executive collaboration and decision support dashboard</td>
<td>3.43</td>
</tr>
<tr>
<td>subcontractor collaboration, work allocation, payments, RFIs</td>
<td>3.42</td>
</tr>
<tr>
<td>Enterprise wide assessment of schedule and budget impact</td>
<td>3.4</td>
</tr>
<tr>
<td>Lessons learned and prior project execution / experience databases</td>
<td>3.39</td>
</tr>
<tr>
<td>Daily work reports, activity, quality log</td>
<td>3.39</td>
</tr>
<tr>
<td>Equipment management, allocation, tracking and expenses</td>
<td>3.35</td>
</tr>
<tr>
<td>Enhancement capability of the quality of documents &amp; reports</td>
<td>3.32</td>
</tr>
<tr>
<td>Proposals, Contracts and Bid management, details and Status</td>
<td>3.26</td>
</tr>
<tr>
<td>Vendor databases, Management, procurements, tracking</td>
<td>3.23</td>
</tr>
<tr>
<td>Partner management, Investment, portfolios and collaboration</td>
<td>3.03</td>
</tr>
</tbody>
</table>

*Note: scale: 1 not at all, 5 extremely significant*