THE USE OF ADVANCED ELECTRONIC MANAGEMENT SYSTEMS TO MANAGE REMOTE PROJECTS IN THE KINGDOM OF SAUDI ARABIA.

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This study investigates the potential use of Advanced Electronic Project Management Systems for managing remote construction projects by the Saudi Electric Company (SEC), in the Kingdom of Saudi Arabia (KSA). The literature review suggests these advanced systems are capable to help companies which have remote projects in KSA or elsewhere to overcome the dilemma of projects' remoteness, reduce unnecessary costs and raise the quality of construction of remote projects. However, little research was undertaken particularly in the gulf region regarding this issue and it has highlighted few unique problems associated with the management of remote construction projects and how far the advanced systems would help to sort out these problems. A pilot study was conducted in 2009 on SEC to set solid grounds for the main survey which explored the views of contractors and SEC's supervision teams about present management systems and practices and how advanced systems would help to improve these practices. The results pointed out the advanced systems would improve some project management practices whereas there are barriers that limit its potential benefits regarding other aspects of project management. Hence, certain adjustments to present project management practices and systems are necessary to overcome these barriers and to ensure that benefits from using these advanced systems can be fully grasped.

Keywords: remote projects, mobile systems, project management, remote manager, virtual management.

INTRODUCTION

In spite of the rapid progress in the construction project management field, construction projects still suffer from problems that affect the project's performance and process. These include tools and systems that are used for communication, co-ordination and management. Yang *et al.* (2007), for instance, suggested that the intense request of project's information and effective communications by the project team can not be met through the use of traditional communications and information management systems as these have their shortcomings and incapable to fulfil project duties and objectives. One of the shortcomings that it provides limited access to information which is considered as one of the key barriers to project management practices (Vadhavkar *et al.* 2002, Pena-mora 2009). Recent studies by Stichiting Bouw Research centre in the Netherlands (2000) indicate that 6 to 7% of the contract expenses can be allocated as expenses due to failures. A lot of these failures are caused by an inadequate organization/ management of the construction process, e.g. a

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weak coordination of processes and uncertainty about available information (Wamelink 2002). These shortcomings have enforced radical changes to traditional project management and communications methods so that new concepts and methods for managing projects were invented. One of these concepts is the golden triangle that initially refers to quality, time and cost but has since been extended to incorporate sustainability, project team and stakeholders' satisfaction and health and safety issues. Advanced Electronic Project Management and communications Systems (AEPMS) such as mobile and Web Based Project Management Systems WPMS that use wireless, Satellite, Internet based or mobile tools and networks have helped construction industry firms to manage the increasing complexity in construction projects and to fulfil the project objectives represented by the quality, scope, saving in time, cost etc. Remote construction projects exist in many regions around the world such as Sahara desert, Antarctic regions, Arabian Peninsula desert etc. The dilemma of the management of remote projects was highlighted by Deng *et al.* (2001) who mentioned that extensive physical distance between project's participants is the main cause leading to delays in decision making. The project team has not to tackle only the traditional management problems – such those highlighted above- but also those that specifically occur as a result of the remote locations of these often environmentally sensitive sites (Kestle and London, 2002and 2003). These sites are often far from any logistic support and suffer a continuous shortage of materials and specialist labour (the same source). In the KSA, remote construction projects represent a unique case. They are in remote locations with rough terrain such as mountains and deserts and in undeveloped and environmentally sensitive regions. They are far away from the supervision team office, contractor's office and major urban concentrations. During the project's construction, supervision teams experience countless difficulties and cumbersome management and supervision problems. This lack of support affects negatively the contractors' ability to sort out construction problems. The building materials' manufacturers experience difficulties in providing deliveries to the site and the construction waste and disposal can not be easily transferred away. These potential factors may affect badly the project quality and causes substantial delay and increase in cost. This study illustrates a case study that is the construction department of Saudi Electric Company (SEC). It examines how the use of AEPMS would be relevant to the SEC's construction project management and help SEC to enhance its management of remote projects. A survey was undertaken on SEC supervisors and engineers, and contractors to find out their views on the potential use of AEPMS by SEC and it investigates whether AEPMS would be applicable to the SEC's management practices.

REVIEW OF THE CURRENT USE OF AEPMS

Some of the remote project management's problems would be avoided – theoretically- if AEPMS are used. These systems include Web based Project Management Systems (WPMS) and mobile systems that include mobile tools, personal digital assistants (PDA), wearable computers, wireless tools etc. These systems have the capability of improving communications between project team members and enabling them to share information and quickly solve problems and this would help them to manage time and cost (Charoenngam *et al.* 2004). Davidson and Moshini (1990) and Bowden (2005) mentioned that the cost of construction can be reduced by 25% through the efficient transfer of information between the construction teams and this can be achieved through the use of AEPMS. Alshawi and Ingirige (2003) and Stewart and Mohamed (2004) have identified the following benefits of using WPMS: productivity

enhancement of communication between project participants, reduction in project delays, heightened all parties' awareness of the project issues, and; 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 travelling time to meetings, avoiding drawings mistakes, reducing time and money spent on disputes, sharing and exchanging project information, automate repetitive routine processes and elimination of paper reports (Alshawi 2003). Thomas *et al.* (2003) discussed how WPMS – from the contractor's selection point of view- can help project's managers would assist in boosting contractor performance and levels of confidence. Nitithamyong and Skibniewski (2004and 2006) have 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, and d) supporting e-commerce and customer. Leskinen (2006and 2008) argued that it would be difficult to make direct assessment of what mobile systems would benefit the construction industry. The most important intangible benefits would include: improved customer service, gaining competitive advantage, more timely management information, supporting core business functions, avoiding competitive disadvantages, improved management information, improved product quality, improved internal communication, change through innovation, improved external communication and job enhancement for employees. Thorpe (2000) pointed out that the Online Remote Construction Management (ORCM) process has the potential to be quite useful for remote construction sites. Superintendents – for instance- do not have to visit the site as often and there is an improved efficiency in project and contract management, better project control, excellent document control, better availability of information for project participants, better decision making, improved management of project knowledge and improved contractual relationships. He mentioned that implementation of ORCM technology should take into account the following issues: the equipment and logistics difficulties, the slow/ unreliable access to the Internet, legal issues regarding the use of electronic communications, cultural issues, the expenses of the implementation of ORCM systems, and the need for staff training.

Despite the fast developments in the IT and the creation of many IT applications for the construction industry, there are still some issues that hinder the applicability of these systems to the construction project management. These can be referred to: IT technical shortages, the way that IT systems are used such as the deployment of the system on "ad-hoc" basis and its' use through isolated project management practices, and these systems would be costive (Alshawi and Ingirige 2003, Nuria 2005 and Leskinen 2006and 2008). The potentiality of IT systems is also hindered by the working environment's characteristics e.g. staff resistance, existing systems and practices that do not enable smooth implementation and use of IT systems (Sidawi 2003). The above literature review suggested that AEPMS would impact positively the project management practices and it may have similar impact on the management of remote projects. The following sections discuss the problems of remote construction sites and the potential use of AEPMS to overcome these problems.

THE MANAGEMENT OF REMOTE CONSTRUCTION SITES

The implementation of AEPMS may not be enough to successfully manage remote sites and management practices should be enhanced as well. Kestle and London (2002) suggested a framework for Design Management for remote sites. The framework emphasizes the following management functions: serving: that is distant

management involves more serving than just leading, controlling: it is the measurement and correction of the performance of the team members' and site activities on daily basis, organizing: the organization structure should establish a formal system of roles that people can perform and be supported in to accomplish enterprise objectives, and economizing: the management's performance should be very economical, emphasizing effective action, efficient organization, optimal plan, and human-centred control together with expertise service. Projects' teams who are located on different and disperse sites communicate and share recourses electronically would be considered as virtual teams and their organization would be defined as a virtual organization. Virtual organizations generally tend to decentralize management. The traditional and hierarchical management structure would change to a more open, interactive collaborated and net structure (Turban *et al.* 1996).

SHORTAGES OF REMOTE PROJECT MANAGEMENT PRACTICES AND SYSTEMS IN KSA

The literature review showed little evidence regarding the remote project management problems around the world and no previous research was found regarding these problems relating to the Gulf region and the KSA. Thus a pilot study was conducted in 2009 by the present research to set grounds for the main survey and define the wording of questions that will be used in the main survey. The examination of the project's archive information and questioning the project engineers/ supervisors at the SEC's regional office revealed the following remote projects management problems.

- The long travel time of four hours and more round trips exhausts the supervisors, especially during the extreme harsh hot weather's period. Due to the staff shortage, supervisors are overloaded with responsibilities. These problems sometimes enforce the supervisor to postpone the site visit even though the visit is vital to. The unsupervised contractors seize this opportunity to use improper construction materials and construction systems.
- The analysis of projects' archive showed that a 30% decrease in the number of visits to the site is associated with an increase in the project's costs by around 30%, and an increase in project's estimated duration by around 20%. This also has affected negatively the project's quality by around 20%.
- Contractors are reluctant to undertake remote projects due to the possible and unpredictable increase in the cost of the labour, materials, transportation, unavailability of basic services for the labour, inaccessible roads etc.
- There is a lack of contractor's commitment to the project schedule due to the difficulties that he usually experiences in providing skilled labour, materials, transportation etc.The lack of construction materials forces the contractor to regularly leave the project site to provide it. This makes the site vulnerable to theft and the records show that there have been several cases of theft of materials and equipments.
- Government authorities responsible for granting permissions are far away from the project site. This remoteness keeps government officers from making frequent visits to the site to do necessary inspections and grant permissions.
- In some remote areas, the initial survey of the project site by the SEC surveyors' shows no definite owner of a specific plot of land. Thus, SEC possesses the land and a budget is allocated for the project. Afterwards a claim of the land ownership by a citizen supported by the approval of the Sheikh (head) of one of the local tribes in the area of the project would raise a legal

conflict over the land ownership and causes substantial delay to the project until the legal dispute would be resolved.

- Delivery of materials and equipments is constrained by roads/ highways regulations. This enforces the contractor to deliver small batches of materials which increases the delivery and transportation cost. In addition, very bad conditions of some remote roads or non existence of roads at some stages makes it very difficult for all project parties to access the project site.

The visit to one of the remote project sites revealed the following notes: occasional site visits are made by the SEC's supervisors to the remote projects site and these infrequent visits cause a delay to the approval of materials' samples; and the contractor sometimes makes changes to the construction works without prior authorization, which contradicts what has been originally specified in the contract.

The pilot study revealed that SEC's supervisors do not use standard forms to write down notes during the site visit. They mainly use mobile phones to communicate with the project personnel and main regional office and use digital cameras to take photos of the construction works. Branches' managers are not authorized to undertake decisions regarding certain management issues and the decision is entirely up to the director of the regional office. This substantially prolongs the decision making period. The present research has also examined an external case study whereas eight engineers from a high profile contracting company in the Eastern Province were asked to fill in a short questionnaire form about the use of AEPMS to manage remote projects. The target of the study was to find out which and how AEPMS are used to manage remote projects and whether the use would reduce the need for the site visit. This case study can be used as good practice to guide SEC of how AEPMS should be used. Unfortunately, the results showed that all types of AEPMS are of little use and the use is not widely spread among the site personnel and supervisors. They said that site visit is needed for the following purposes: to choose samples, to correct any changes that are committed by the contractor and affect the scope of the project, and sort out safety issues. Some types of information such as contract specifications, contract drawing, revisions to submittals are heavily (i.e. 11-20 per week) requested and information such as these related to materials' are very heavily (i.e. 21-50 times per week) requested by the project's personnel. There is no evidence whether this very frequent request has been dealt with immediately or not. The pilot study's results were used to design the main survey's questionnaire. The questionnaire was divided into two sections. The first section asks the participants about the type of electronic or traditional management systems and tools that are used at present and who uses it. Also, it asks about the frequency of the site's queries – and these queries were extracted from the pilot study- and their impact on the project's performance and process. Section two asks about the AEPMS that they would recommend using to manage remote construction projects. The participants were asked how far these recommended systems would help in sorting out construction problems; and these problems were again extracted from the pilot study. It asks about potential barriers that would hinder the implementation of AEPMS. The targeted population consists of contractors and SEC's supervisors/ engineers who are located in the four regions of KSA. This targeting method would provide feedback from the two major project's parties, which would increase the applicability of the proposed AEPMS to both of them. In 2009, one hundred questionnaire forms were sent randomly out. Twenty five supervisors/ engineers and two contractors responded back and this represents 27% of the targeted population. The main survey revealed that AEPMS and tools are of little

use by contractors and supervisors. Most of the respondents (i.e. 70%- 89%) said that they use traditional communication systems and tools such as fax, mobile, site visit, weekly and monthly reports and weekly/ monthly meetings to make communications between the remote project site and the supervision office and to manage jobs. They do not use mobile systems and tools apart of the mobile phones which are used by 93% of the respondents. All respondents do not use web cams or construction robots on site. The WPMS is not used and the email service is used by 67% only. Respondents said that electronic communications and management systems are widely unused among the project team members. Around third of the respondents surveyed said that queries related to the following stages: Finishes works, Concrete works, Insulation materials works and Openings (i.e. doors and windows) works take 1-3 days to be sorted out. Nearly the same percentage of respondents said that queries would take 4-6 days to be sorted out during the above mentioned stages and for Mechanical and Electrical works' stages. 48% said that queries that related to Masonry works' stage take the same period to be sorted out whereas around 30% said it would take 4-6 days. 33%- 41% said that queries during the Mechanical works and Telecommunications and Computers works' stages take one to two weeks to be sorted out. Respondents agreed that the delay in sorting out a number of issues affect badly the project performance – represented by cost, time, scope and quality criterions- and the project process; these are arranged from more effective to less effective as the following: mistakes in construction works, poor quality of construction works (project's performance only), the selection of unskilled workers by the contractor to work on site, shortage in site equipments, unavailability of materials, low productivity of the workers, changes to specifications/ specified materials (project's process only), ineffective planning and scheduling of the project by the contractor, and breakdown of one of the site equipments (project's performance only).

In regards to the use of AEPMS tools, 82% of the respondents recommended the use of E-mail service. 74% of them recommended the use of mobile tools, 40% to 48% recommended the use walkie-talkie and web monitoring camera, 22% to 30% recommended the use personal digital assistants and tablet computer, and 33% recommended the use of WPMS. Respondents said that the recommended AEPMS would be mainly helpful in sorting out the following construction problems: mistakes in construction works, delay in the project timetable, changes to the project's scope; and the specifications/ specified materials and the increase in materials' cost during the building's construction. Meanwhile, the recommended AEPMS was considered of little help in sorting out the following issues: the contractor's use of improper construction methods, the selection of unskilled workers by the contractor to work on the site, inadequate equipments that are used, problems related to the transportation of materials to the site and the delay in approving contractor's submissions by the SEC Engineers. Respondents considered the implementation of the following electronic tools would have a positive impact on the following aspects of projects (i.e. decreases cost and time and increases quality and scope): project scheduling tools, efficient administrative tools, effective Collaboration tools, site monitoring tools and cost Management tools. Meanwhile, other tools such as procurement management, Communications, and exchange of information tools were considered to have a little positive impact on these project aspects (see Table 1). Respondents said that barriers that mainly hinder the implementation of advanced electronic management and communications systems in SEC are (Table 2): the management system (i.e. the organization structure and practices), concern of some technical issues such as cost,

maintenance and support, the difficulty to make changes in organization's structure, internal influences, external pressures and the level of IT skills of staff.

DISCUSSION AND CONCLUSIONS

The findings of this research are discussed below emphasizing on the potential barriers that limit the applicability of AEPMS to the SEC's construction project management and how these barriers can be overcame. It showed that construction department at SEC experiences a number of problems regarding the management of remote construction projects such as non standard construction processes, security of the site, transportation, trust between the contractor and supervisor, contractor's commitment, excessive construction costs, employment of unskilled labour, lack of materials and equipments and non standard control and management methodologies that are used by supervisors. The decision making is entirely up to the director of the regional office which causes delay in making decisions. Present traditional management mechanisms are not capable to sort out the present project's problems and queries took long time to be sorted out.

Table 1: Positive/ negative impact of AEPMS implementation on various aspects of the project (Scale: Cost and time aspects: -1 increase, 0 neutral, 1 decrease; and quality and scope aspects: 1 increase, 0 neutral, -1 decrease). Note: a positive Mean value indicates positive impact and a negative Mean value indicates negative impact.

System tools	Cost	Quality	Scope	Time	Mean value of the impact
Project scheduling tools	0.09	0.75	0.2	0.62	0.42
Efficient administrative tools	0.09	0.74	0.3	0.52	0.41
Effective Collaboration tools	0.00	0.6	0.21	0.47	0.32
Site monitoring tools	-0.32	0.64	0.47	0.48	0.32
Cost Management tools	0.09	0.37	0.32	0.47	0.31
Document Management tools	-0.1	0.5	0.35	0.33	0.27
Information analysis tools	-0.14	0.50	0.41	0.23	0.25
Procurement Management tools	-0.14	0.33	0.37	0.37	0.23
Communications, exchange of information tools	-0.27	0.41	0.38	0.38	0.23

The main survey found that some issues would affect badly the project performance – represented by cost, time, scope and quality criterions- and the project process. A number of barriers would impact the implementation of AEPMS such as the AEPMS's cost, maintenance and support, the SEC's management system, the organization readiness to change, and the level of IT skills of staff (see similar findings by Nitithamyong and Skibniewski (2004), Yang *et al.* (2007); Walker *et al.* (2005); Vileneuve *et al.* (2003) and Chan *et al.* (2004)). Respondents considered that AEPMS would provide little help in sorting out the following issues: the contractor's use of improper construction methods, the selection of unskilled workers by the contractor to work on the site, inadequate equipments that are used, problems related to the transportation of materials to the site and the delay in approving contractor's submissions by the SEC Engineers. Moreover, they anticipated that some tools such as procurement management; communications, and exchange of information tools would have little positive impact on various project aspects (i.e. cost, quality, time and scope). In conclusion, the level of the AEPMS applicability to SEC's project management is hindered by – the above mentioned- negative characteristics of the SEC's environment, shortages of AEPMS systems and its' possible incapability to

meet the unique management demands of remote projects. As illustrated in the previous section, each of these negative characteristics or barriers has its' level of significance/ impact and this should be taken into account by SEC when considering the adoption of AEPMS. To increase the level of applicability of AEPMS to the SEC's remote project management practices, the following measures are recommended.

- Existing electronic systems should be examined to find out whether they can be integrated smoothly with the new AEPMS.
- Factors that significantly influence the remote projects' performance and processes should be incorporated in the design of the new AEPMS.
- A number of technical capabilities that highlighted above should be embedded in the new AEPMS; and.
- The new AEPMS should be linked with the contractors' systems.

Table 2: Barriers that hinder the implementation of advanced electronic management and Communications systems in SEC. (Scale: 1 does not hinder to 5 highly hinders)

Barriers	**Level of hindrance out of 5 (Mean value)**
The management system i.e. structure and practices	3.52
Concern of some technical issues such as cost, maintenance and support	3.04
The difficulty to make changes in organization's structure	3.00
Internal influences	3.00
External pressures	2.92
The level of IT skills of staff	2.92
Degree of organizational readiness to adopt IT	2.79
Perceived benefits by staff	2.50
Degree of the organization's openness to external sources of information	2.48
The management commitment and perceptions of ICT benefits	2.36

The implementation of the AEPMS would not be successful until certain changes are made to the present management practices. These practices – in comparison with Kestle and London (2002, 2003) framework- seem to be non standard, inflexible and loose. It should be redesigned and remote management abilities of managers should be improved to enable them to virtually manage the remote project sites. The following adjustments are essential to the exiting project's management practices.

- Negative factors that highly affect the management of remote projects should be investigated and proper mechanisms should be created to sort it out.
- Proper plans should be set for staff training and staff should be informed about the benefits and advantages of the new system. However, training is also essential for the contractors' staff.
- Flexible decision-making mechanisms should be created and tested.
- Proper mechanisms for controlling and monitoring the recruitment of site personnel by contractors, and shortage of manpower and so on should be designed and applied.

However, some problems seem to be generated during other stages of the project. For instance, issues regarding expected problems (such as site personnel recruitment and the transportation of materials) in addition to unforeseen problems (such as possible shortages in manpower and the breakdown of equipment) 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 remote examination of the quality of construction work, monitoring the productivity level of site workers, and calculation of the rate of material consumption. Eventually, the SEC should direct the contractor's attention to the unique problems and unforeseen issues associated with the construction of remote projects. That way, the contractor would have a chance to assess their potential negative impact on the remote project.

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