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MANAGEMENT PROBLEMS OF REMOTE CONSTRUCTION PROJECTS AND POTENTIAL IT SOLUTIONS: THE CASE OF KINGDOM OF SAUDI ARABIA

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SUMMARY: *Remote projects have their unique problems that are caused mainly by the remoteness of the project itself thus the loose control over communications and management. This is due to a number of reasons such as lack of management skills, human resources and infrastructure. Little research was undertaken particularly in the gulf region regarding this issue and it has highlighted few unique communications and management problems. This paper investigates the current problems that the Saudi Electric Company (SEC), Kingdom of Saudi Arabia (KSA) experiences regarding the management of its' remote construction sites. It discusses the opinions of contractors and the SEC's supervision teams regarding the weaknesses in the present communications and management practices. The study found systematic project management problems that have profound negative impact on remote projects' performance and process. The paper suggests that some of these problems can be sorted out by the use of Advanced Computer based Management Systems (ACMS) and these would improve some project management practices. However, organizational barriers may hinder the potentiality of these systems thus changes to the organization's management system and practices should be carried out to achieve full benefits.*

KEYWORDS: *Mobile systems, Web-based project management systems, remote manager, virtual management.*

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1. INTRODUCTION

In spite of rapid progress in the project-management field, a number of negative issues still affect management of construction projects. These issues include use of inappropriate tools and systems for communication, coordination, and management. For example, Yang et al. (2007) suggest that intense need for project information and effective communications by the project team cannot be met by traditional communications and information management systems since these systems have shortcomings and are incapable of fulfilling project duties and objectives. One of these shortcomings is that traditional systems provide limited access to information, which is considered one of the key barriers to successful project management practices (Vadhavkar et al., 2002; Pena-mora et al. 2009). Recent studies by the Stichiting Bouw Research centre (2000) indicate that 6% to 7% of contract expenses are due to failures such as unnecessary inefficient process that do not meet the agreed quality of the end product, and repairs. Many of these failures are caused by inadequate organization and management of the construction process (e.g. a weak coordination of processes and uncertainty about available information) (Wamelink 2002). These shortcomings brought about radical changes to traditional project management and communications methods such that new concepts and methods for managing projects have been invented. One of these concepts is the golden triangle, a concept that initially referred to quality, time, and cost but now extends to include sustainability, project team and stakeholder satisfaction, and health and safety issues (Atkinson 1999).

Remote construction projects exist in many regions throughout the world such as the Sahara desert, Antarctic regions, the Arabian Peninsula desert, etc. The dilemma in managing remote projects is highlighted by Deng et al. (2001), Kestle and London (2002, 2003), Kestle (2009), McAnulty and Baroudi (2010), and Thorpe (2000). These authors have pointed out that the remoteness thus the loose control is major cause of the management problems. They suggested possible causes such as the lack of human resources, infrastructure and experience of how to manage these remote projects. In the KSA, Saudi Electric Company (SEC) engages in a number of remote construction projects. These projects are of different sizes and range from electric power plants to warehouses and customer service blocks. They are in remote locations with rough terrain such as mountains and deserts and operate in undeveloped and environmentally sensitive regions. They are far from the supervision team office, the contractor's office, and major urban concentrations. During construction, all project parties experience countless difficulties and cumbersome management problems. These potential problems negatively affect project quality and cause substantial delays and increases in costs.

The literature review suggests that some of these management and communications problems can be sorted out by the use of Advanced Computer based Management Systems (ACMS) such as mobile and Web-based Project Management Systems (WPMS). These systems use wireless, satellite, Internet-based, or mobile tools and networks and it helps - to a certain degree - construction industry firms manage the increasing complexity of construction projects. They have also helped fulfil project objectives such as quality, scope, time, and cost. In the KSA, remote construction projects represent a unique case. These projects have certain characteristics such as they are remote and difficult to access, thus it is difficult to frequently monitor and control the project processes and outcomes, and to provide supplies to the site. Thus, during construction, supervision teams experience countless difficulties and cumbersome management problems with respect to the supervision of the site. This lack of support negatively affects the contractors' ability to sort out construction problems. The remoteness of the projects also complicates the building permission process, as it is extremely difficult for government inspectors to visit the site regularly. The building material manufacturers experience difficulties in providing deliveries to the site, and the construction waste and disposal cannot be easily transferred away. These potential problems may negatively affect the project quality, cause substantial delays and increases in cost and imply all project parties to higher risk chances in comparison with traditional nearby projects.

2. REVIEW OF CURRENT REMOTE PROJECTS MANAGEMENT PRACTICES

The dilemma of managing remote projects is highlighted by Deng et al. (2001), who mentions that the extensive physical distance between project participants, sometimes extending over national boundaries, is the primary cause of delays in decision making. The project team has to not only tackle traditional management problems but those that specifically occur as a result of the remote locations of these often environmentally sensitive sites (Kestle 2009; Kestle and London 2002, 2003). These sites are often far from logistic support and suffer a continuous shortage of materials and specialized labour (Kestle and London 2002, 2003). Kestle (2009) investigated the management problems of remote project through two case studies: one a humanitarian project in West Darfur, Al Sudan and the other a drilling project of a scientific expedition in the Antarctic region. Kestle (2009) reports lack of project pre-planning, certainty, and/or clarity concerning project process integration. There were also misinterpretations and miscommunications of project results and needs issues. A centralized decision-making process and lack of delegated authority to field personnel often hindered progress and communications at critical emergency response and recovery stages.

Kestle & London (2002) suggest a framework for the design management of remote sites. The framework emphasizes the following management functions:

- Serving: remote management involves more serving than simply leading;
- Controlling: measurement and correction of team member performance and site activities on a daily basis;
- Organizing: the organizational structure should establish a formal system of roles that people can perform and be supported by to accomplish the enterprise's objectives. The key factors for the management of remote sites are value generation, knowledge integration, process integration, and timely decision-making. Project teams located at disperse sites and that communicate and share recourses electronically are virtual teams; their organization is defined as a virtual organization. Virtual organizations generally tend to decentralize management. The traditional and hierarchical management structure changes to a more open, interactive, collaborative, and network structure (Turban et al. 1996). A crucial aspect of remote project success depends on effective sharing of knowledge and information among the different people and the building of trust among remote project teams (Uden& Naaranoja 2007); and
- Economizing: management's performance should be economical, emphasizing effective action, efficient organization, optimal planning, and human-centered control with expertise service. The overall objective is cooperation to derive maximum benefit for the enterprise.

McAnulty and Baroudi (2010) conducted a survey of top and mid-tier construction contractors with experience in remote construction projects in Australia. They found that contractors experience difficulty attracting and retaining skilled workers; working in remote locations has a negative impact on an employee's family life. It is difficult to procure and access materials and equipment in remote areas and severe climatic factors in remote areas have a negative impact on productivity. There is lack of infrastructure and communications. The researchers suggest a number of possible solutions such as the need for appropriate material management systems and design cost information specifically for remote construction works. They recommend that unique types of costing issues should be included in the project's cost estimation at the pre-construction stages of project; these include: mobilization/demobilization, accommodation, inclement weather downtime, site allowances, delivery, and productivity.

3. REVIEW OF THE CURRENT USE OF ACMS

Some of remote project management's problems can be avoided if ACMS were used. These systems include WPMS and mobile systems that feature mobile tools, personal digital assistants (PDA), wearable computers, wireless tools, four dimensional augmented reality and other technologies. These systems possess the capability to improve communications between project team members and enable teams to share information and quickly solve problems. They improve team members' ability to manage time and costs (Charoenngam et al., 2004). Davidson & Moshini (1990) and Bowden (2005) state that construction costs can be reduced by 25% through efficient transfer of information between the construction teams; that transfer can be achieved through ACMS. Ahuja et al. (2010) suggest that adoption of Information Communication Technology (ICT) enables effective communication between dispersed project team members but argues that strategic adoption of ICT (i.e. by a number of organizations involved in the construction process) requires that all supply chain members follow accepted methods of communication or protocols. This enables them to grasp effectively the IT benefits (Ahuja et al, 2009).

Alshawi and Ingirige (2003) and Stewart and Mohamed (2004) identify the following benefits of using WPMS: productivity enhancement of communication between project participants, reduction in project delays, heightened awareness of project issues among all parties, and ease of access to and retrieval of project information. Other advantages include: avoiding delays due to the arrival of updated drawings and documents, reducing visits to sites and travelling time to meetings, avoiding drawing mistakes, reducing time and money spent on disputes, sharing and exchanging project information, automating repetitive routine processes, and eliminating paper reports (2003). Thomas et al. (2003) discuss how WPMS - from the point of view of selecting contractors - helps project managers boost contractor performance and confidence by minimizing subjectivity and eliminating the potential for corrupt practices. This improves competitiveness through increased awareness of competitors' strengths and weaknesses and nurtures mutual trust in the exchange of sensitive information such as performance data. Nitithamyong and Skibniewski (2004, 2006) suggest that benefits of using WPMS can be categorized into four main areas. These categories include cost reduction and time saving, enhancement of communications and collaboration, improvement of productivity and partnership, and support of e-commerce and the customer. A number of researchers anticipate that WPMS will replace traditional project management methods (Becerik 2005; Zou and Roslan 2005) and these methods are drivers of WPMS adoption. Several aspects support this claim including increased competitive pressures, expectations of revenue growth, the ability to compete globally, and the desire to reengineer the business to respond to market challenges (Nitithamyong & Skibniewski 2006).

Leskinen (2006, 2008) argues that it is difficult to make direct assessment of which mobile systems would benefit the construction industry. The most important intangible benefits include improving customer service, gaining a competitive advantage, acquiring more timely management information, supporting core business functions, avoiding competitive disadvantages, improving management information, improving product quality, improving internal communication, implementing changes through innovation, improving external communication, and enhancing the jobs of employees. In recent years, the development of laser scanning and video and image-based 3D reconstruction system is enabling remote and virtual walk through on actual construction sites. These systems have the ability to minimize the travel times of supervisors and may increase the frequency of progress, quality and safety inspections by providing project supervisors with systems that are easily applicable (Golparvar-Fard et al 2011, Jaselski et al 2011). The utilization of Building Information Modelling (BIM) by the project team would provide a more streamlined business process, associated project and site management methodologies including complete facilitation of construction knowledge during the full lifecycle of a building project (Arayici and Aouad, 2010).Thorpe (2000) points out that the Online Remote Construction Management (ORCM) process has the potential to be useful to remote construction sites. He mentions that the implementation of ORCM technology should take into account equipment-related and logistical difficulties - particularly on the remote site; access to the Internet, which can be slow or unreliable; legal issues regarding use of electronic communications; cultural issues such as staff reluctance to change existing practices; ORCM systems implementation expenses; and the need for staff training.

Despite fast developments in IT and the creation of many IT applications for the construction industry, some issues still hinder the applicability of these systems to construction project management. There is a problem with regard to the diffusion of IT in the construction industry and the absorption of IT into work practices. This includes the level of strategic IT investment by construction industry firms (Alshawi et al. 2009). Other barriers include IT technical shortages, deployment of the system on an ad hoc basis, isolated project management practices, and costly systems (Alshawi and Ingirige 2003; Nuria 2005; Leskinen 2006, 2008). Sidawi and Omairi (2010) found several barriers to the implementation of WPMS at Royal Commission of Jubail, KSA including staff resistance to change work methodology and processes, low levels of IT infrastructure of the organization and other parties, low computing proficiency levels of senior management & staff, concern for major investment without guarantee of success and/or returns, and preference for old-style paper-based/existing management protocols. To minimize these barriers and enable ICT adoption, the following issues should be investigated (Margherita and Petti 2010):

- Strategy: the action plan deriving from an integrated view of organization’s goals and priorities, people expectations, and potential benefits;
- People: the single individuals’ attitude and the overall organizational context which impact on the level of willingness and readiness to change;
- Process: the real unit of analysis and trigger of change in terms of alternative redesign scenarios and associated impact; and
- Enablers: the potential facilitators of implementation at technological and organizational level

Although there are barriers to IT adoption as highlighted above, the literature suggests that ACMS can impact project management practices positively. The following sections discuss remote construction site challenges and how ACMS should be designed to overcome these problems.

4. THE RESEARCH METHODOLOGY

This paper examines a case study that is the use of ACMS by the construction department of the Saudi Electric Company and whether the use would help SEC improving the management of remote projects. This research is conducted on two stages. Firstly, a pilot study (i.e. examination of the project's archive brief interviews and observation of one of the sites activities) was conducted by the present research in 2009. This is due to the lack of previous research regarding remote projects' within the Gulf region and the KSA and to define and test the wording of questions that are going to be used in the main survey. This approach is recommended by many researchers such as Morse (1991) and Oppenheim (1992). Secondly, the pilot study's results were used to design the main survey's questionnaire which was carried out in 2009. The questionnaire is 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 how far these queries would affect badly the project's performance and process. Section two asks about the ACMS that they would recommend using to manage remote construction projects. They were asked how far these recommended systems would help in sorting out construction problems; and these problems were again extracted from the pilot study; and how far the use of electronic communications and management tools would improve the management of remote projects. It asks about potential barriers and how far these barriers would hinder the implementation of ACMS. 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 ACMS 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 majority of respondents were SEC's staff, the results expresses about the views of SEC staff rather than the contractors. Simple statistical tools such as the Percentage and the Mean were used to analyze the data. The study however is limited to SEC's remote sites whereas SEC's supervision team members do not live on these sites.

5. SHORTAGES OF SEC'S REMOTE PROJECT MANAGEMENT PRACTICES AND SYSTEMS

In KSA, SEC has a number of remote construction projects. The construction process of these projects is divided into the following stages: site work; concrete work, masonry work, insulation materials for heat and humidity work, openings (e.g. doors and windows) work, finishing work (e.g. walls, ceilings, and floors), mechanical work (e.g. plumbing, air conditioning, and fire protection), electrical work, and telecommunications and computer work. SEC adopts a management methodology for remote projects similar to those of traditional projects. A pilot study was conducted in 2009 to find out more about management problems. It examined three projects' archives, questioned several project engineers/ supervisors at SEC's regional office, and included a visit to one of the remote sites. The pilot revealed the following issues:

- Long travel times of four or more hours during round trips exhaust the supervisors, especially during extreme hot weather. Due to staff shortages, supervisors are overloaded with responsibilities; each has two or more remote sites to inspect. These problems sometimes force the supervisor to postpone necessary site visits. Unsupervised contractors seize this opportunity to make changes to construction plans and use improper construction materials and inadequate construction systems to cut costs. The result is poorer quality construction.
- Contractors are reluctant to undertake remote projects due to unpredictable increases in costs of labour, materials, transportation, and unforeseen circumstances. They are also concerned with unavailability of basic services for labourers such as housing, services, roads, etc. These factors sharply reduce the contractor's profit margins.
- There is a lack of contractor commitment to the project schedule due to the difficulties that they usually experience in providing skilled labour, transportation, etc.
- Lack of construction materials forces contractors to leave the project site regularly to procure them. This absence makes the sites vulnerable to thefts and records show that there were several cases of materials and equipment thefts.

- Government authorities responsible for granting permissions are far from the project site. The remoteness keeps government officers from making frequent visits to the site to perform necessary inspections and grant permissions.
- In some remote areas, the initial survey of the project site by SEC surveyors showed no definite owner of a specific plot of land. Thus, the SEC would possess the land and a budget was allocated for the project. Afterwards, a claim of ownership by a citizen (supported by the Sheikh [head] of one of the local tribes) would raise legal conflicts over land ownership and cause substantial delays to the project or even halt the project until the legal dispute was resolved.

Delivery of materials and equipment is constrained by road/highway regulations. These conditions force contractors to deliver small batches of materials, which increases delivery and transportation costs. In addition, the bad conditions of some remote roads or the non-existence of roads at some stages make it difficult for all project parties to access the project site. The pilot study revealed that SEC's supervisors do not use standard forms to write down notes during the inspection of construction sites. They primarily use mobile phones for communication and digital cameras to take photos of the project's progress. Supervision teams use e-mail to communicate with the director of the regional office. Branch managers are not authorized to undertake decisions regarding a specific site's queries and decisions are left entirely to the director of the regional office. This substantially prolongs the decision-making period.

The pilot study results were used to design the primary study's questionnaire. The questionnaire asks participants about the frequency of the site's queries - extracted from the projects' archive - and how badly these queries affect a project's performance and process. It also asks participants about the type of electronic or traditional management systems and tools presently used and which ACMS they recommend to manage remote construction projects. They were asked how much these systems would help in improving management practices and sorting out construction problems; these problems were extracted from the pilot study, including the projects' archive. It asks about potential barriers and how much these barriers would hinder implementation of ACMS. The targeted population consisted of contractors and SEC's supervisors/ engineers located in the four regions of KSA. This targeting method provides feedback from the two major project's parties, which would increase the applicability of the proposed ACMS to both of them. In 2009, one-hundred questionnaire forms were sent out randomly. Twenty five supervisors/ engineers and two contractors responded representing 27% of the targeted population. The majority of respondents were SEC staff so results expressed the views of SEC staff rather than the contractors. The primary survey found that queries take four to six days to be sorted out during finishing, concrete, insulation, openings, mechanical, and electrical work stages. 33% to 41% said that queries during the mechanical and telecommunications/computers work stages take one to two weeks to be sorted out. Respondents agreed that the delay in sorting out queries negatively affects project performance - represented by cost, time, scope, and quality criteria - and the project process. Arranged from greatest to least, the most negative impacts are in regard to the delay in sorting out the following queries (see Table 1 and Tables A-1 and A-2 in appendix A):

- Mistakes in construction works
- Poor quality of construction works (project performance only)
- Selection of unskilled workers by the contractor
- Equipment shortages
- Unavailability of materials
- Low productivity of workers
- Changes to specifications/specified materials (project process only)
- Ineffective planning and scheduling of the project by the contractor
- Breakdown of site equipment (project performance only)

TABLE 1: The degree of impact of the delay in sorting out remote site queries/ problems on the project process and performance (Column number two scale: 1, does not affect to 3, heavily affects. Column number three scale: 1 positive, 0 neutral, -1 negative)

Type of queries/ problems	**Level of negative impact of the delay on project process**	**Mean value of the negative impact of the delay on project performance** *(represented by cost, quality, scope, and time criterions)*
Mistakes in construction works	2.63	-0.48
Poor quality of construction works	2.62	-0.24
The selection of unskilled workers by the contractor to work on site	2.54	-0.44
Shortage in site equipment	2.54	-0.39
Unavailability of materials	2.52	-0.46
Low productivity of the workers	2.48	-0.49
Changes to specifications/ specified materials	2.44	-0.23
Ineffective planning and scheduling of the project by the contractor	2.42	-0.39
Improper construction methods implemented by the contractor	2.38	-0.32
Problems related to the transportation of materials to the site	2.3	-0.36
Delay in the approval of contractor submissions by the SEC engineers	2.26	-0.25
The increase in materials' cost during the building's construction	2.22	-0.27
Change of the project's scope by the contractor	2.15	-0.19
Unavailability of SEC engineers on the remote project's site due to their workload	2.15	-0.34
Delay in the project timetable	2.11	-0.3
SEC tendering system that obligates the choice of the lowest bidding value	2.08	-0.19
Inadequate equipment used	1.96	-0.29
Delay in conducting of the field survey by the contractor	1.92	-0.29
Unavailability of SEC engineers during sample testing	1.88	-0.35
Personnel safety issues	1.85	-0.06
Breakdown of equipment on site	1.81	-0.42

It is found that ACMS are of little use to contractors and supervisors. Most of the respondents 70% to 89%) said they use traditional communication systems and tools such as fax machines, mobile phones, site visits, weekly/monthly reports, and weekly/monthly meetings to manage jobs and communicate between the remote project site and the supervision office. They do not use mobile systems and tools apart from mobile phones, which are used by 93% of the respondents. None of the respondents uses web cams or construction robots on site. The WPMS is not used and e-mail services were used by only 67%. Respondents indicated that electronic communications and management systems are widely unused among project team members. With regards to the potential use of ACMS, 82% of respondents recommended use of e-mail services. 74% recommended use of mobile tools, 40% to 48% recommend use of walkie-talkies, fax, and web monitoring cameras, 22% to 30% recommend use of personal digital assistants and tablet computers, and 33% recommend use of WPMS.

Respondents said a ACMS would be especially helpful in sorting out the following construction problems: mistakes in construction works, delays in the project timetable, changes to the project's scope, changes to the specifications/specified materials, and increases in the costs of materials during construction (see Table A-3 and A-4 in appendix A). Generally speaking, the implementation of ACMS would have positive impact on various aspects of the project (see Figure 1). However, the respondents were concern about the impact of implementation of electronic project scheduling; and communication and exchange of information tools on the project cost (see Figure 1). They said that the barriers that hinder the implementation of advanced electronic management and communications systems in SEC are primarily the management system (i.e., the organizational structure and practices); concerns over technical issues such as cost, maintenance, and support; difficulty in making changes to the organization's structure, internal influences, external pressures; and the level of staff IT skills (see Figure 2).

6. DISCUSSION

The findings of this research are discussed emphasizing the potential benefits of ACMS to SEC and the barriers that limit the applicability of ACMS to SEC's construction project management; special emphasis is given to how these barriers can be overcome. This study suggests that the construction department at SEC experiences a number of unique problems. Other researchers such as Deng et al. (2001), Kestle and London (2002, 2003), Kestle (2009) and McAnulty and Baroudi (2010) report similar problems. These problems can be categorized as follows:

A. Human Resources: SEC has a staff shortage so employees are incapable of doing all required site visits. This has negative implications for the project since some uncommitted contractors seize this opportunity, make changes to construction plans, and hire unskilled workers. There is a lack of security and shortage in skilled workers. Government authorities are not able to visit the site frequently due to remoteness of the projects and inaccessible roads. The impact of the harsh working conditions on the productivity of SEC's supervisors has been briefly outlined in this study but the research did not inspect its impact on the productivity of the remote site's personnel.

B. Cost, time, scope, and quality management: There is serious delay in sorting out a number of project queries and problems; these have a bad effect on the project's performance and process. Delays in decision-making, loose control, and infrequent visits to the remote site result in wasted time, excessive costs, unfocused scope, and poor construction quality.

C. Procurement and risk Management: There is a frequent shortage of materials. This undoubtedly shows that procurement and supply of materials is not accurately planned by the SEC or its contractors. Contractors are reluctant to undertake remote projects due to unpredictable increases in the cost of the labor, materials, transportation. Delivery of materials and equipment is constrained by road/highway regulations and bad conditions of some remote roads. With traditional methods of running a remote project by both sides (SEC and the contractors), projects have much higher risk margins than ordinary projects. These results from an ad hoc approach and both sides do not accurately plan projects.

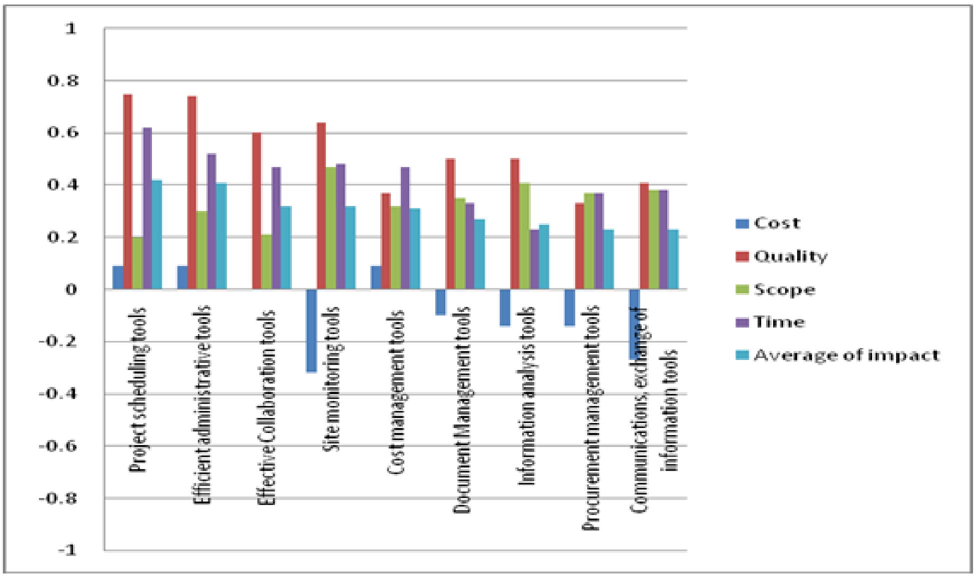

FIG 1: Potential positive/ negative impact of ACMS implementation on various aspects of the project (Scale: cost and time aspects: -1 increase, 0 neutral, 1 decrease; quality and scope aspects: 1 increase, 0 neutral, -1 decrease)

D. Infrastructure and communications: Land ownership in some remote areas is not definite or known; legal disputes are likely to occur. There is a lack of or no infrastructure such as services, materials, and equipment. The survey demonstrates that contractors and SEC supervisors still use traditional communications and management tools and that ACMS is little used by project team members. Decisions are made autocratically since they are made solely by the director of the regional office. It is clear that SEC project managers are not able to control and coordinate integration of a project's aspects and the typical management style is non-standard, fragmented, and loose. Communications problems may take place even with the installation of any prospective ACMS. This is due to a number of potential barriers related to the project, SEC, and the ACMS itself. The top barriers include ACMS costs, maintenance and support, the management system, organizational readiness to change, and the IT skill levels of staff (Chan et al. 2004; Nitithamyong and Skibniewski 2004; Villeneuve et al. 2003; Walker et al. 2005; Yang et al. 2007). Traditional management practices are also an obstacle of ACMS full utilization.

7. CONCLUSION

The problem of managing remote construction sites operates at different levels. These problems should be examined to enable SEC to grasp fully the potential of ACMS. This researcher recommends these actions at the following levels:

A. Strategic planning level: despite the fact that strategic planning is not considered in this study, planning at the strategic and project levels is closely linked. Therefore, SEC should set up a strategy with respect to management of all remote projects. More research is needed regarding this matter.

B. Project level: Design and pre-planning of site activities such as supply and human resources should consider the environment and project variables mentioned above. Flexible decision-making mechanisms should be created and tested. Present project management practices should be redesigned and remote manager abilities should be improved. SEC should consider short and long-term partnering with contractors. This includes linking systems and sharing information and management tools. This would enhance knowledge integration and help to foster innovative ideas that dramatically improve projects (Barlow 2000). During the construction stage, precise daily control and follow-up procedures should be applied regarding issues such as remote examination of work quality, monitoring productivity of site workers, and calculation of material consumption rates. Some problems seem to be generated during other stages of the project; some are expected such as recruitment of skilled workers, transportation of materials, and other unforeseen problems such as possible shortages in manpower and breakdown of equipment. These should be studied and resolved at the initial planning stages of the project. Emergency scenarios should be established at the early stages of the project to deal with unexpected issues. Prior to any engagement, SEC should draw the contractor's attention to the unique problems and foreseeable issues associated with the construction of remote projects.

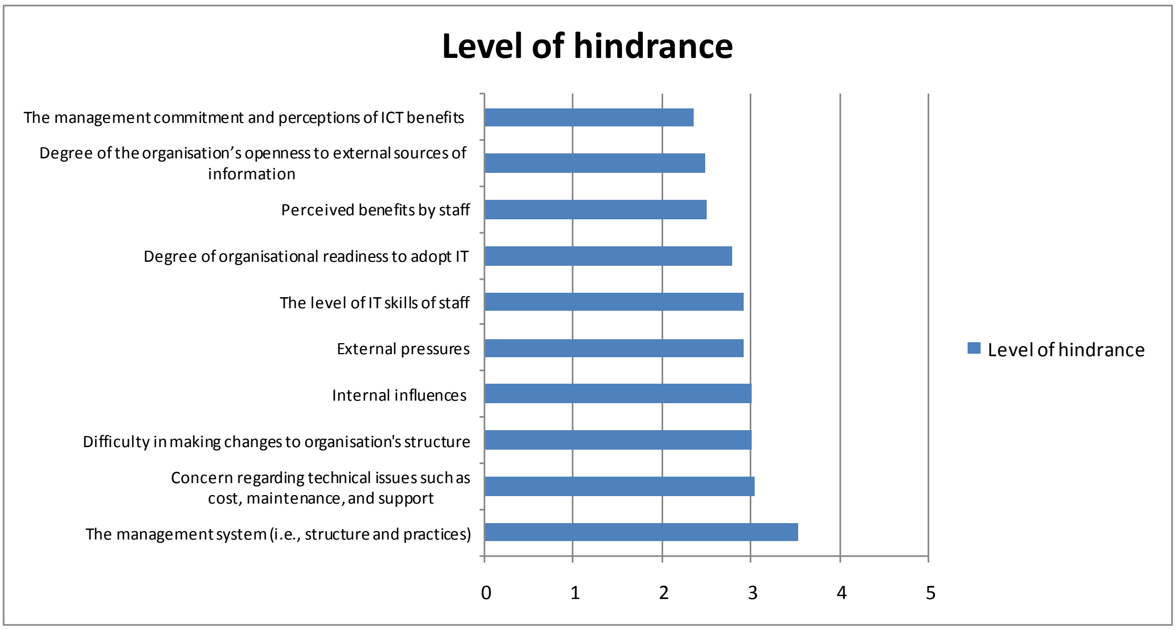

FIG 2: Barriers that hinder the implementation of advanced electronic management and Communications systems in SEC. Scale: 1 does not hinder to 5 highly hinders

C. Staff level: Proper plans should be adopted for SEC's staff and contractor training; staff should be informed about the benefits and advantages of new ACMS systems. Managers should be trained on how to manage remote sites virtually.

D. ACMS level: Design of the new ACMS should be discussed with the SEC contractors and supervisors and to find out their views, perceptions and expectations. This would take into account the present remote project's processes and future scenarios for project processes. The ACMS design should consider how to reduce the negative impacts of the project and environment variables on project performance and processes. To minimize the current barriers and the negative impacts on projects, ACMS should be capable to offer help on two levels: a) vertically during the project life from the design and planning stages through the tendering stage until the occupation/use stage and b) horizontally by integrating all the project parties' systems, knowledge, and information along the supply chain.

This researcher understands the limitations of the case study presented in this paper with regard to the number of participants. However, this could be used as foundation work for future research, which investigates in-depth the problems and possible IT solutions for other remote projects in KSA.

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Appendix A

TABLE A-1: The negative impact of delay in sorting out remote site queries/ problems on the project process. Scale: 0 does not affect, 1 somehow affects, 2 heavily affects. Note: sample size 27, missing values are not shown in this table

	Negative impact on project process			
Type of Query/ problem	**Does not affect (%)**	**Somehow affects (%)**	**Heavily affects (%)**	**NA (%)**
Mistakes in construction work	0	37	63	0
Delay in the project timetable	0	78	19	0
Change of the project's scope by the contractor	4	40	41	4
Personnel Safety issues	18	52	19	4
Changes to the specifications/ specified materials	4	37	55	0
Poor quality of construction works	4	29	63	4
The increase in materials' cost during the building's construction	11	56	33	0
The selection of unskilled workers by the contractor to work on site	4	37	55	4
Low productivity of the contractors' workers	4	44	52	0
Unavailability of materials	4	29	63	0
Problems related to the transportation of materials to the site	7	56	37	0
Ineffective planning and scheduling of the project by the contractor	7	40	48	5
Unavailability of SEC engineers on the remote project site due to their workload	11	52	33	0
Delay in the approval of contractor submissions by the SEC engineers	0	52	41	0
Shortage in site equipment	4	37	55	4
Delay in conducting of the field survey by the contractor	18	63	11	8
SEC tendering system that obligates the choice of the lowest bidding value	7	48	30	8
Unavailability of SEC engineers during sample testing	7	60	18	4
Breakdown of one of the site equipment	22	60	11	3
Improper construction methods implemented by the contractor	11	37	48	4
Inadequate equipment used	18	63	15	4

TABLE A-2: The impact of delay in sorting out remote site queries/ problems on the project performance. (Scale: cost and time criterions: -1 increase, 0 neutral, 1 decrease; quality and scope criterions: 1 increase, 0 neutral, -1 decrease). Note: sample size 27, missing or N/A values are not shown in this table

	Project performance												
		Cost			Quality			Scope			Time		
Type of delay	**Irrelevant (%)**	**Decrease (%)**	**Neutral (%)**	**Increase (%)**	**Decrease (%)**	**Neutral (%)**	**Increase (%)**	**Decrease (%)**	**Neutral (%)**	**Increase (%)**	**Decrease (%)**	**Neutral (%)**	**Increase (%)**
Mistakes in construction work	3	7	15	65	63	29	3	3	63	25	4	4	85
Delay in the project timetable	11	4	30	48	7	67	8	4	63	11	8	7	71
Change of the project's scope by the contractor	15	11	33	33	22	48	8	11	41	30	11	11	60
Personnel Safety issues	26	4	41	22	8	33	22	0	56	11	4	33	26
Changes to the specifications/ specified materials	0	14	29	40	29	43	14	15	48	22	7	26	56
Poor quality of construction works	0	30	18	30	74	3	4	15	44	11	26	30	30
The increase in materials' cost during the building's construction	7	8	15	66	18	56	15	8	74	7	4	48	37
The selection of unskilled workers by the contractor to work on site	4	18	33	30	74	7	8	15	60	11	4	7	74
Low productivity of the contractors' workers	0	11	11	63	48	41	7	11	67	7	0	11	85
Unavailability of materials	7	4	22	48	22	52	4	12	52	7	0	4	85
Problems related to the transportation of materials to the site	3	4	30	52	11	63	8	8	60	11	0	11	82
Ineffective planning and scheduling of the project by the contractor	4	7	22	63	18	63	4	7	56	15	3	3	86

Unavailability of SEC engineers on the remote project site due to their workload	15	4	52	18	67	11	4	10	60	10	7	33	41
Delay in the approval of contractor submissions by the SEC engineers	11	0	48	30	4	56	15	5	56	12	4	4	74
Shortage in site equipment	0	8	33	40	40	30	15	11	52	15	3	4	82
Delay in conducting of the field survey by the contractor	4	4	44	26	22	48	11	4	59	7	7	7	74
SEC tendering system that obligates the choice of the lowest bidding value	30	30	11	18	40	15	7	15	30	11	15	15	37
Unavailability of SEC engineers during sample testing	11	8	52	11	60	22	0	15	44	8	4	26	37
Breakdown of one of the site equipment	4	4	22	52	26	44	8	11	52	7	4	15	70
Improper construction methods implemented by the contractor	4	11	26	37	52	11	18	11	48	11	11	18	56
Inadequate equipment used	4	18	30	30	44	37	0	4	55	11	8	18	52

TABLE A-3: Level of help that the advanced technology would provide to sort out construction problems/ queries. Note: sample size 27, missing or N/A values are not shown in this table

Issues to be sorted out	**Do not know (%)**	**Not at all (%)**	**Somehow (%)**	**Neutral (%)**	**Helpful (%)**	**Very Helpful (%)**
Mistakes in construction work	0	0	11	15	11	60
Delay in the project timetable	0	11	4	15	18	48
Change of the project's scope by the contractor	11	22	11	4	19	26
Personnel Safety issues	0	19	11	18	14	34
Changes to the specifications/ specified materials	4	22	4	15	22	30
Poor quality of construction works	0	15	4	15	26	37
The increase in materials' cost during the building's construction	7	30	15	7	0	30
The selection of unskilled workers by the contractor to work on site	7	15	11	19	15	26
Low productivity of the contractors' workers	4	18	15	7	22	26
Unavailability of materials	4	11	4	22	11	33
Problems related to the transportation of materials to the site	4	11	8	22	18	30
Ineffective planning and scheduling of the project by the contractor	4	4	22	15	18	30
Unavailability of SEC engineers on the remote project site due to their workload	7	4	7	12	15	44
Delay in the approval of contractor submissions by the SEC engineers	7	19	7	19	7	30
Shortage in site equipment	7	19	18	8	18	15
Delay in conducting of the field survey by the contractor	7	26	7	22	11	19
SEC tendering system that obligates the choice of the lowest bidding value	22	22	7	15	8	15
Unavailability of SEC engineers during sample testing	4	14	11	12	22	26
Breakdown of one of the site equipment	11	4	18	11	19	26
Improper construction methods implemented by the contractor	4	11	7	7	30	30
Inadequate equipment used	7	11	7	19	26	15

TABLE A-4: Level of help that the advanced ACMS would provide to sort out construction problems/ queries. Note: sample size 27. Scale: 1 does not help, 5 extremely helpful.

Issues to be addressed	**Level of helpfulness (Mean value)**
Mistakes in construction work	4.23
Delay in the project timetable	3.92
Change of the project's scope by the contractor	3.75
Changes to the specifications/specified materials	3.69
The increase in materials' cost during construction	3.54
Personnel safety issues	3.48
Unavailability of SEC engineers during sample testing stages	3.40
Breakdown of one of the site equipment	3.40
Poor quality of construction works	3.35
Shortage in site equipment	3.25
Unavailability of SEC engineers on the remote project site due to workload	3.23
Delay in conducting the field survey by the contractor	3.13
Low productivity of the contractors' workers	3.12
SEC tendering system that obligates the choice of the lowest bidding value	3.04
Ineffective planning and scheduling of the project by the contractor	3.04
Unavailability of materials	3.00
Improper construction methods implemented by the contractor	2.80
The selection of unskilled workers by the contractor to work on the site	2.65
Inadequate equipment used	2.64
Problems related to the transportation of materials to the site	2.58
Delay in the approval of contractor submissions by the SEC engineers	2.08