

## Facilities of Information Technology in construction industry

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### Abstract

The work of many authors involved in construction described and documented the interesting development and increasing in use of Information Technology (IT). These works reveals that data and information of construction industry had been entered in and/or generated by software programs and represented in many different formats used by the many disciplines involved in the industry. The increasing in use of IT is because of its facilities in all the ramifications of construction industry. The purpose of this study is to focus on the facilities that IT provides by presenting suitable application in one of the construction industry organizations. Methodology of this study is highlighting the benefits, roles, drivers, advantages and disadvantages of using IT in construction industry to clarify facilities that can be gated by implementing IT in construction industry and the reality of the event IT in implementation process. A comprehensive and extensive review of literatures ranging from books, theses and articles were carried out to establish the framework of the study that covers IT and its application in construction industry. Preliminary finding of this study proves the important effect of applying IT in construction industry by its facilities through the many activities of construction process. Also using IT can reduce some documentation problems, improves coordination and collaboration among firms participating in construction projects and leading to better communication practices.

**Keywords:** Information Technology; construction industry.

### Introduction

Bulky amounts of documentation are generated and exchanged between the individual (often unique) parties contractually bound to the construction project because the construction industry is an information intensive industry: where this information intensiveness can also be a barrier to the overall goal of industry collaboration. Quantities of documentation being created continue to rise; depending on the type of project being undertaken which results in the operatives almost being submerged in information (Sommerville, 2006).

Stewart (2002), Kanoglu (2005-2006), Vachara (2004) defined IT depends on its usage because the diversity of use has led to a number of different IT definitions. The information-centric definition is the use of electronic machines and programs for the processing, storage, transfer and presentation of information (Stewart, 2002). A brief definition of IT is a tool of documentation, processing and exchanging information between all participants that using IT facilities.

IT is developing apace and maybe it will be the dominated form of business communication between organizations in the near future, and Implementations of IT in construction industry have attracted increasing worldwide attention (Stewart, 2002).

Information technology (IT) has a facility in describe and document the work of many disciplines involved in construction firms, firms information and data processing in software programs or generated by computer programs (Fischer & Kunz, 2004).

The application of IT in construction industry mostly satisfied by software systems (e.g. ERP System), ERP system has benefits in coordinating process and information, reducing carrying costs, decreasing cycle time and improving responsiveness to customer needs (Wikipedia, 2007).

In general, IT in construction consist the use of all electronic means of information transfer (computer networks, local area networks LANs, internet, mobile phones, faxes, etc). We can say Also, IT is the last technology, such as knowledge-based systems, computer-based decision support systems and object-orientated CAD.

There are some examples of IT applications failing to achieve satisfactory levels of adoption because many problems and difficulties come together with the starting of IT implementation and there is a need to analyze the advantages and disadvantages of IT application at the IT test level (Stewart, 2002). An example of IT application is an electronic procurement system known as eP in 1999 in the finance ministry of Malaysia. eP allows transactions between government agencies and suppliers to be conducted electronically (Mastura, Abdul Rashid, Ramayah & Basri, 2007). This study focusing on IT facilities by clarifying benefits, utilizations, and role to encourage the implementation of IT in construction industry.

### **History of IT development in Construction Industry**

Many efforts have been applied to improve construction productivity; IT can increase productivity through decreasing information processing time (Howard, 2004). IT applications can also improve operational improvement through improving the communication flow of information for effective decision-making and coordination. For example, the use of visualization technologies can improve the effectiveness of communicating project information between project participants (Liston, Fischer & Kunz 2000).

In the 1970s, a lot of research was focused on the use of stand-alone IT applications in the construction industry to improve productivity of specific construction processes or problems. These construction IT applications were developed on computer mainframes to assist construction operations, support decision-making and prediction of outcomes of uncertain processes (Vachara, 2004). By the 1980s, computers had been used in large construction firms as a result of the low cost of hardware and its demonstrated efficiency in calculating and processing construction information (Vachara, 2004). Software applications that have been used at that time were included administration, accounting, estimating, planning, database and simulation (Lester, 1984). Computer aided design (CAD) was developed and used since the mid-1980s. In the late 1980s, there was some research undertaken in robotics, automation and knowledge-based construction systems. Also, the concept of IT integration was developed, for example to integrate construction process information and integrate time planning with cost control (Suckarieh, 1984). In the 1990s, a trend evolved in which individual IT systems for designing, planning, estimating, cost control and CAD were integrated into an organization-wide IT system (Doherty 1997b, Howard 1998). This integration also included knowledge based systems and simulation. Innovative technologies such as barcodes, pen-based computers, portable computing and multimedia were also introduced for managing construction operations during this time. In addition, computer science research in the field of expert systems, artificial intelligence and management information systems (MIS) were applied to construction management (Vachara, 2004). Since 1995, IT related computer applications such as Virtual Reality, 2D & 3D barcodes, and 4D-CAD, handheld devices, Internet and remote access have been developed to improve efficiency in construction processes (Aouad, 1998, Aouad, 1999). From the literature review of abstracts in many journals, it is evident that IT innovations related to Internet and communication technology (ICT) have been increasingly used in construction projects over recent years (Walker & Betts 1998). The interest in doing researches and surveys about the implementation of IT in construction industry had been increased in many countries for example in Canada (Rivard 2000); Saudi Arabia (OBrien & Al-Biqami 1999); Hong Kong (Futcher & Rowlinson 1998, 1999); Denmark (Howard & Samuelsson 1998); Finland (Howard & Samuelsson 1998); New Zealand (Doherty 1997a); and others.

ICT innovation opens greater opportunities for construction information integration, so it can help to remove problems of construction fragmentation (Garcia, 1998). Several ICT innovations have been developed to help enhance the generation and flow of construction documentation (Aouad, 1999). One of the benefits of using ICT is that all information is created and stored in electronic media formats so that it increases the capability for users to simultaneously and concurrently access and share information in different geographical areas (Hajjar & AbouRizk, 2000). Benefits of ICT application use in construction are also supported by several research studies (Akinsola, Dawood & Hobbs 2000, Anumba & Duke 1997, Garcia 1998, Opfer 1997, Orth 2000, Tam 1999).

### **Importance of IT in Construction Firms**

Many construction firms have problems with effectiveness and efficiency of their workflows. An international investigation pointed out that there is a need to strengthen the industries innovation e.g. by increasing use of information technology and increasing collaboration with education and research institutes (Kjeld & Per, 2006). Construction management needs to be involved with IT, because IT

requires organizing and planning in line with the business requirements. If order rather than chaos is to emerge then a clear strategy on IT is essential (Hollingworth, 1986). Public agencies in many countries have plans for the dissemination of construction information to participating organizations, and new technologies are being tested to make this possible. Many problems with data exchange standards and classification, have to be solved before texture and graphical information can be shared among divers applications in separate organizations.

In most of the world economies the construction industry has suffered from poor productivity and also from poor profitability, as in other sectors of the economy, strategic importance of Information Technology (IT) comes in focus when these problems are being discussed. IT has become the solution to the strategic problem that arises from current economic force such as globalization, deregulation, political turmoil, etc. IT has become of strategic significance in modern business from a position of being a support technology for information processing (Betts, 1999).

Huge Volumes of information exists in any construction project, large number of parties and multiple different points of view, mostly, can cause lost of information during the construction process (Howell, 1996) (Figure 1). The best sharing of information between the participants in any construction project satisfied by using IT tools to ensure fast exchanging of information and reduce errors and these achieve large improvements in the efficiency, productivity and quality of the building industry.

By the survey of Tucker (1996) and the two projects of Kjeld & Per (2006) it can be recognized the importance and benefits of IT in construction industry as following:

- 1- Availability of IT reduces the need of rework by facilitate the exchanging process of data and information between all parties of construction work.
- 2- IT can improve the communication processes between all parties.
- 3- The construction industry relies heavily on informal communication, which is considered reliable by all participants.
- 4- IT applications, that is, computers, software systems and mobile phones, are tools can be used by participants for best documentation, less errors and real time transferring of the information about site conditions to the management.

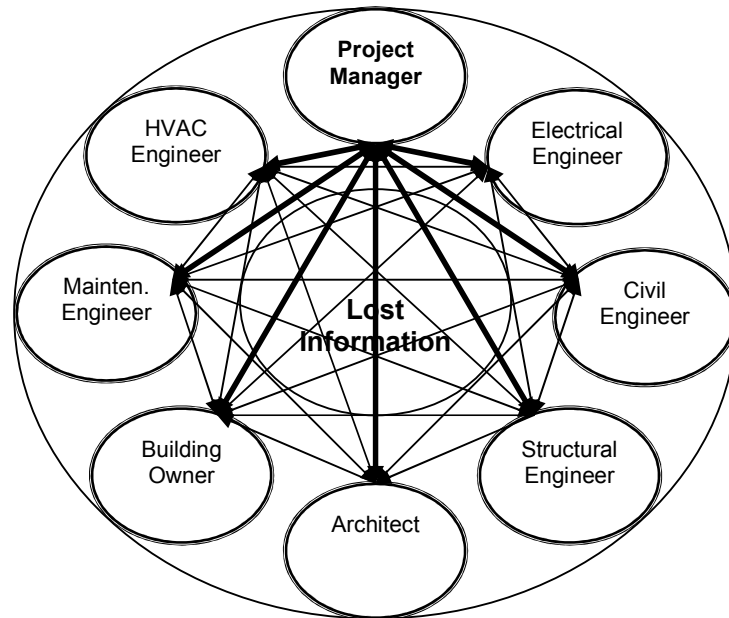


Figure 1: losing information during the construction process

### IT Role in Construction Process

The role of IT can be considered from three standpoints: the tool used in each of the various stages of a construction project i.e. pre tender, post-tender and post-completion. Also, how IT affects procurement and the eventual routes adopted for each project and organization. Finally IT impact on the humans involved in the delivery of the construction project (Sommerville, 2006). IT role by supporting such predictions where practitioners will utilize IT to simulate, analyze, and evaluate the

expected performance of the facility design, the design of the facilities delivery process (design and construction schedule), and the design of the organization carrying out the process. These simulations, analyses, and evaluations should be based on an integrated model describing the designed facility, organization, and process. The simulation, analysis, and evaluation results should then be visualized so that the results make clear what the tradeoffs are between optimizing the facility, organization, and process design for a particular discipline vs. the overall project for the wide range of criteria typically found on construction projects. IT role is by support the simulations, analyses, and evaluations as much as possible. Eventually, IT will support the optimization of a projects design from the perspective of multiple disciplines (Fisture & Kunz, 2004).

Kjeld and Christiansson, (2006) argued the important role of IT in construction firms when Implementing IT system to capture the using of time and materials on projects, recording data on time consumption as well as use of materials and equipment, have a daily efficient reporting of time, material and equipment use on each project.

In the late 1990's, some parties at construction organizations are increasingly aware of IT role and its value-adding potential and are appreciating the strategic opportunities it provides. Construction firms can use IT for process improvement, innovative approaches to engineering and construction problems, client satisfaction, management of competitors, and new contract and procurement systems (Betts, 1999).

### **Benefits of IT Implementation**

There are a number of reasons have been put forward as to why the construction industry has not really been able to fully benefits from IT by improve information flows. These reasons are in additions to the more conventional ones of top management awareness, this quest of standards and the problems of participation, and relate to limitations imposed by the technology on mechanisms for co-operative working (Alty, 1993). Some firms found major strategic advantage through using IT in response to local market opportunity (Betts, 1999). The use of IT improves coordination and collaboration among firms participating in construction project, leading to better communication practices. Its practical benefits, for example, include an increase in quality and reduce in time of documentation, an increase in speed of work, better financial controls and communications, simpler and faster access to common data, and a decrease in documentation errors (Nitithamyong & Skibniewski 2004).

The Enterprise Resource planning ERP System has huge benefits by implementing in construction industry, for example ERP benefits are: coordinating process and information, reducing carrying costs, decreasing cycle time and improving responsiveness to customer needs (Wikipedia, 2007). The benefits ICT in the construction firms is introducing opportunities for enhancing communication to improve many construction processes at each level of project realization as well as creating new business opportunities, these benefits motivated numerous of construction firms to adopt and invest ICT (Vachara, 2004).

To gauge the strategic advantage that provided by using IT, an effort appropriate to the local circumstances will be necessary. One such approach would be a government-led, industry-wide effort. At this level, information is potentially shared and communicated extensively, across professional boundaries and throughout the construction process. This strategic effect of such an effort is likely to be improvements in the external competitiveness of the industry as a whole. This is the most beneficial and broadest level at which IT strategy can be applied (Betts, 1999).

As computing technology continues to develop, the following benefits begin to emerge (Howard, 2004):

1. Construction firms recognize the value and importance of knowledge assets. Knowledge management systems will be more widely used at the project, organization and industry levels;
2. Object-oriented CAD systems will become the norm. they will be used as a design and modeling tool, rather than just a presentation tool;
3. Physical performance simulations will become part of virtual prototyping during the design development process;
4. E-tendering and e-procurement will become widely used;
5. 4D (3D plus time dimension) modeling will provide a visual tool for project planning and scheduling. Mobile device will be widely used at construction sites;
6. More intelligent devices will be used to control the operation and maintenance of buildings in an integrated fashion; and
7. Product data technology will become mature. Data and process standards will eventually lead to whole life cycle integration.

### **Advantages of IT**

A. Weippert & P.A. Tilley (2002) argued the following advantages of IT:

1. Better understanding and appraisal of the client's requirements and this will help to ensure that the project delivers is what the client expects.
2. Closer team work through better communication.
3. Better integration of the procurement and operation processes.
4. Reduction in time lost compared to conventional communication methods such as phone, mail or courier.
5. Lessened impact of geographical separation of team members.
6. Faster access to a greater volume of relevant data from anywhere in the world.
7. The information being available online and capable of being automatically referenced by project applications.

By the successful implementation of information technology into the construction industry, the various project participants can benefit from the following advantages (Stockdale 1998, Mohamed, Tilley and Tucker 1999, Neo 1998):

• The Client:

1. Better quality finished product because energies are focused on the ultimate goal and not misdirected to adversary issues;
2. More control over potential cost overruns and delays;
3. Better planning control;
4. Development of teams for future projects;
5. Open communication and unfiltered transfer of information for more efficient resolution of problems;
6. Increased opportunity for innovation through open communication and element of trust, especially in the development of value engineering and build ability improvements;
7. Increased opportunity for a financially successful project because of non-adversarial win-win attitude.

• The Design Team:

1. More open involvement in the control of variations;
2. An interactive team member in providing interpretation of design intent and solutions to problems;
3. Optimal use of design time;
4. Communications during design reviews to eliminate possible errors or omissions due to an enhanced role in the decision making process;
5. Involvement of all project participants during cost budgeting;
6. Development of teams for future projects;
7. Increased opportunity for a financially successful project because of non-adversarial win-win attitude.

• The Contractor:

1. Increased opportunity for value management involvement;
2. Faster decision making processes;
3. Faster response to Request For Information (RFI) through the construction phases;
4. More effective use of time and cost control;
5. Increased chances for innovation, build ability, productivity and quality;
6. Repeat business;
7. Development of teams for future projects;
8. Increased opportunity for a financially successful project because of non-adversarial win-win attitude.

• Sub-contractor:

1. Faster response to Request For Information (RFI) through the construction phases;
2. Potential to improve cash flow due to fewer disputes and withheld payments;
3. Improved decision making avoids costly claims and saves time and money;
4. An enhanced role and voice as an active team member;
5. Repeat business;
6. Development of teams for future projects;
7. Increased opportunity for a financially successful project because of non-adversarial win-win attitude.

• Manufacturers and Suppliers:

1. Timely approval of product recommendations and Request For Information (RFI);
2. Potential to improve cash flow due to fewer disputes and withheld payments;
3. Improved decision making avoids costly claims and saves time and money;
4. An enhanced role and voice as an active team member;
5. Involvement in the co-ordination with other project trades;
6. Better chance for quality in the products installation;
7. Repeat business;
8. Development of teams for future projects;
9. Increased opportunity for a financially successful project because of non-adversarial win-win attitude.

### **Disadvantages of IT**

The following points are the disadvantages of IT for construction team (A. Weippert & P.A. Tilley, 2002):

1. The acquisition of suitable staff, hardware, phone lines, data storage and the system to safeguard the integrity of data and maintain the network.
2. A company's operation can be affected if the computer system fails and electronic documents are unavailable.
3. Entry mistakes can have a greater impact on project outcomes compared to traditional non-electronic means.
4. Although security measures such as encryption are available, their effectiveness against unauthorized and serious intrusions remains unproven.
5. Operating in a 'virtual office', staff may lose the benefits from the more dynamic face-to-face interaction.

### **Barriers of IT Implementation**

Number of case studies was used to illustrate the use of IT in construction industry and its barriers to implementation (Baxendale, 1999). The barriers are to the use of IT in the structure of the organization, and its general lack of IT implementation planning at a strategic level.

The benefits of IT may not be achieved if its application tools are hindered by what is described below as barriers to implementation (Tucker & Mohamed, 1996):

- 1- Due to many senior managers who, through the lack of system knowledge/understanding and being unconvinced of the immediate gains that could be achieved from IT applications.
- 2- Additional resources are required during the course of IT implementation. These resources are either financial (purchasing the hardware and software), or human (education and training).
- 3- Lack of time for training and changing operations is taken into account when considering IT implementation.
- 4- Any changes to work processes are disruptive to productivity, especially during the introduction phase and more so if the introduction is not known in advance.
- 5- People, no matter how dedicated to the new tools, usually have a tendency towards doing things the way they are used to.
- 6- No awareness of suitable software.
- 7- The security of data and possible theft;
- 8- The user expectations may not be met;
- 9- The size of the job required to afford the necessary overheads; and
- 10- The need to train site staff.

The following actions can prevent these barriers (Tucker and Mohamed, 1996):

- 1- Well-defined purpose.
- 2- Planned initiative.
- 3- Commitment to implementation.
- 4- Efforts by Project Management and users to satisfy the success requirements of IT implementation.

Griffith, Zammuto & Aiman-Smith (1999) assert that the barriers that cause IT failure are the invisibility problems of implementation such as overestimation of a new IT initiative's value or lack of concern for people-related issues. They suggested that project managers should focus on implementation-related issues such as funding, support, and realistically estimating an initiative's technology benefits.

At any construction organization, to overcome these barriers, Senior Project Manager has to control directly Business management and management commitment, selection of IT application depending on the technical need is one of the factors support the strategic plan of the construction organization (Figure 2) (Tucker and Mohamed 1996, A. Weippert & P.A. Tilley 2002).

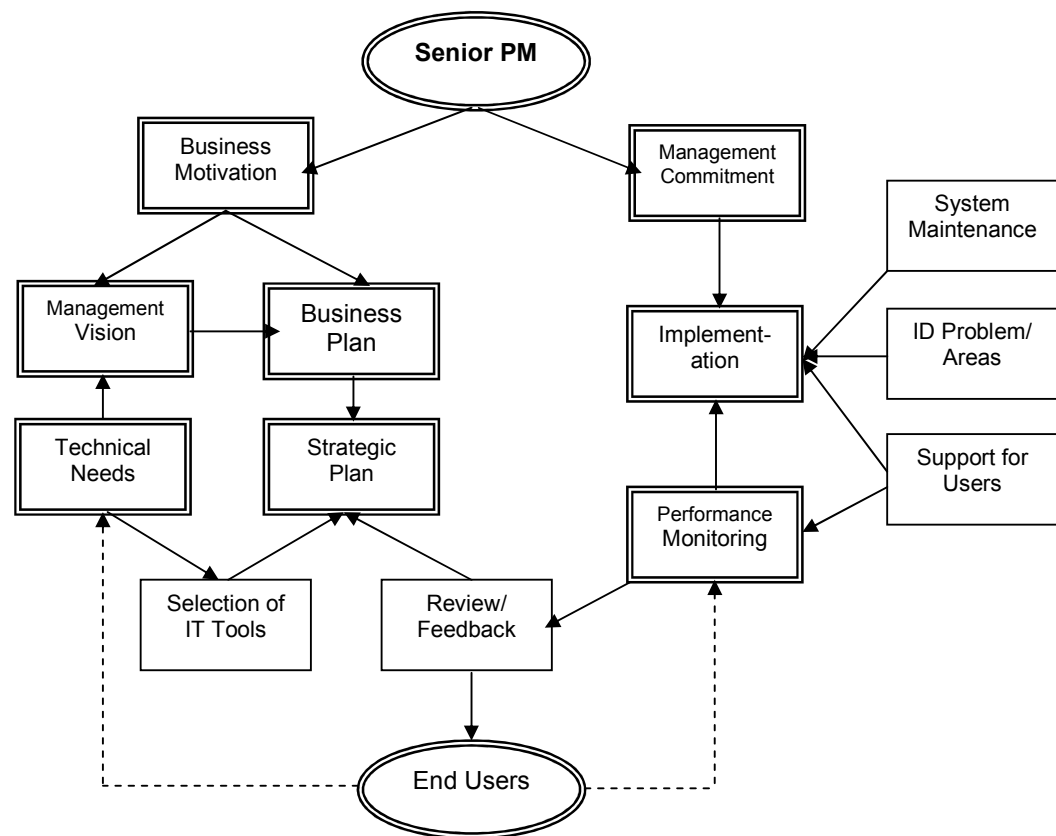


Figure 2: model of IT implementation process at any construction organization

### Drivers of IT Implementation

Project management were aware of the IT developments taking place but are prevented from introducing the new technology due to budget restrictions, continuing with paper based methods until company management decides otherwise. The adoption of IT innovations into the construction industry will not happen until strategic decisions are made showing a benefit from an increased expenditure in IT implementation (Baxendale, 1999).

Devising of Eden and Chen (2000) in an examination of the progress made of information technology in the construction industry identifies the following drivers:

- 1- Growth and wider use of the Internet for electronic commerce and communication has provided the information intensive construction industry with a tool for transferring reliable information.
- 2- The International Alliance for Interoperability - Australasia Chapter, and the development of Industry Foundation Classes at an international level and its practical uses on real projects. The term Interoperability is defined by Yum and Drogemuller (2000) as “the exchange of information between separate computer programs without the loss of content or meaning.”
- 3- Various Governments are providing leadership and direction through the development and implementation of policies on the use of information technology.
- 4- Technology is increasingly being accepted by business managers, clients, community and workforce and becoming a necessary part of the way they work.

## Conclusions

The success of realization process for any construction project depends largely on good communication between all parties that participate in project realization; one of the new and important facilities of IT is the communication between numbers of participant in the same time to satisfy real time connection with/between all project realization parties. Also IT provides a digital based for documentation, exchanging data and information to reduce errors and time and this widely support the team work of construction project in up to date getting, exchanging data and information.

There is an important positive effect of applying IT in construction industry, this effect when IT has become of strategic significance in modern business from a position of being a support technology for information processing. Using IT can improves coordination and collaboration between all parties that participating in construction project, leading to better communication practices and this can enhancing quality and reduce time of documentation to increase speed of work. Construction organizations are increasingly aware of IT and its value-adding potential and are appreciating the strategic opportunities it provides. ICT gave greater opportunities for the integration of construction information and that can help to remove problems of construction fragmentation. The root cause of IT failure is the invisibility problem of implementation such as overestimation of a new IT initiatives value or lack of concern for people-related issues.

Due to many senior managers who, through the lack of system knowledge/understanding and being unconvinced of the immediate gains that could be achieved from IT applications. The success of IT at any organization in construction industry needs efforts by Project Management and users to satisfy the success requirements of IT implementation.

Finally, the integration between selected tools of IT and participants in construction project satisfy better communication, faster implementation and reduce errors.

## Recommendations

Mostly, IT diffusion is limited in some large construction firms especially in developed countries. Even in these firms, there are some problems that come together with the beginning of IT implementation, particularly in the integrating of IT system with the old system, so there are a real need for more practical studies of IT implementation, also it is important to train and provide courses for all participants that involved in IT implementation.

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