



Project Report

on

**“The use of mobile computing technology to enhance the construction management process”**

by

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*Abstract*

The construction industry has historically been fraught with difficulties associated with the management of projects in terms of lack of adequate communications between design teams and site management. A major reason for this lack of communication has been the slow pace of uptake of information and communication technology (ICT) among managers at site level even though the technology has become more affordable and easier to utilise. The following report will look at the technology and devices available to site personnel that can enhance the construction management process. It will also look at the inherent issues that exist within the construction industry in terms of the cultural attitudes towards change.

*Keywords.* Communication, Mobile computing, Culture, Information.

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## ***1. Introduction***

It is widely accepted that the AEC industry is rife with inefficiencies and also has problems in terms of productivity and quality management in the delivery of projects.

Over the past number of years, the management of construction projects has benefited to varying degrees from the advances in Information and Communications Technology (ICT) by way of more efficient and speedy transfer of information along with the reduction in costs of doing so. With the advent of smartphones and tablets, the sharing of information between the design team, contractor and trades has become more efficient and quicker. Most of these devices are equipped with wireless communication capability and with the ever increasing availability of 3G and 4G connectivity, even remotely located sites can avail of the technology. Software vendors are also constantly developing applications and subsequent reduction in costs of devices and software means that even the smallest of contractors can make use of ICT to streamline their operations.

However, while some large construction firms may have begun to use ICT in their day to day operations, a lot of small to medium enterprises (SMEs) have yet to be convinced as to the benefits of using such technology. To understand why some construction companies have not adopted ICT we must consider the culture that exists within the Architectural, Engineering and Construction (AEC) sector in terms of, 'we have always done it this way'.

## ***2. Background***

Historically the AEC industry has relied on paper based information sharing as the standard method of communication of design data and ideas. However, due to the sheer volume of information required for the construction process, this paper based method has always been prone to errors or omissions. With the development of Computer Aided Design (CAD) in the eighties, drafting became more efficient but all construction drawings and specifications were still paper based and not always very accurate. When errors were noticed by site management it would be necessary for them to submit a Request For Information (RFI) in writing to the architect which, depending on the level of cooperation between the contractor and architect, could take several days to get a satisfactory response. As these inaccuracies or errors usually only come to light at construction stage it is at this point that works schedules begin to be affected with a corresponding rise in costs to the client and or the contractor.

The advent of Building Information Modelling (BIM) in the late nineties brought about the prospect of great change within the AEC industry with promises of paperless communication between all involved in the industry. However, as the construction industry has been described as fragmented, requiring vast quantities of information and often times very adversarial (Cox, 1998), this communication is often lacking even for the simplest of tasks. Samuelson (2002) noted that the dramatic change anticipated was becoming more elusive in a climate where business leaders were sceptical as to the potential benefits that ICT could bring to their organisation. Having said that, there is fairly widespread use of information technology at upper management level within the industry. However, as the actual process of construction takes place on sites, there has been a reluctance on the part of management to implement ICT at site level.

The lack of rational attitudes by personnel towards technology within the AEC industry was observed by (Davis, 2008), who also went on to note that personal motivation was a major factor in ICT adoption. This brought to the fore the human dimension that would need to be considered when introducing new technologies to an organisation. (Brewer, 2006) Although the capabilities of ICT used in the construction industry are advancing at an ever increasing rate there still seems to be a low level of uptake within the industry and this human factor would appear to be one significant reason for this.

### ***3. Problem description***

The profit margins of construction projects can be as low as two or three percent therefore there is always a need to make the whole process as efficient as possible in order to ensure these profits can be maintained or increased. Part of the problem with lack of efficiency lies with the inadequacy of communication of information between management and site personnel. While ICT is used widely at design stage to communicate information between designers and construction company managers it is vastly under utilised by contractors and site workers involved in the actual construction process.

Construction managers, site managers and foremen need to be on site to coordinate the works, ensure adherence to health and safety regulations and document completed and ongoing construction work. They also need to be at their computer in the site office in order to communicate with the design team, subcontractors and client as well as to order equipment and materials. This leads to managers feeling that they have to be in two places at once; on

site coordinating the works as well as being in the site office doing the administration (Löfgren, 2006).

This scenario brings to the fore the need for ICT systems to be put in place that can minimise the time wasted by managers and site personnel going to and from the site office in order to access information and or instructions. This is particularly the case when it comes to buildability issues. As construction projects have become more complex, there is often a lack of details in the construction drawings as to how the elements can actually be put together and as such there can be a great deal of time wasted trying to get clarification from the architect regarding these details. One estimate shows that nearly 30% of all quality problems on site were due to unclear project information. (Snook, 1995) This lack of clarity inevitably leads to delays in the project, which in turn affects the cost and often leads to animosity between the contractor and architect. On a personal note I have witnessed this hostility manifest itself to the point where a contractor would have to factor in extra moneys in his quotation to allow for the delays he knew would occur when a certain architect was in charge of the project for which he was quoting.

The example just mentioned highlights what is probably the most prevalent issue when it comes to the implementation of ICT within the AEC industry and that is the one of the culture that exists in terms of resistance to change. The term “we’ve always done it this way” is often used as a reason not to change work practices and this attitude is widespread in the industry, from the professional classes to the site workers.

‘Culture’ could be described as difficult to understand and the following are some of the many interpretations of the word:

- *“Is a pattern of shared basic assumptions that has been learnt whilst solving problems, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems”* (Shein, 1997)
- *“Is influenced by traditions, myths, history and heritage...it is the sum of how we do things around here”* (Hensey, 2010)
- *“Begins to form whenever a group has enough common experience”* (Shein, 1999)

- *“Pervades the decision-making and problem-solving process of the organisation, influencing the goals, means and manner of action...thereby underlining much of the human activity in an organisation” (Williams, 1993)*

The need for cultural change is becoming more evident as the rapid change in technology has begun to transform the AEC industry and how it operates. With the potential improvements in competitiveness that can be achieved as a result of implementing an ICT policy into an organisation, the only other mechanism for these organisations to improve competitiveness is to consider the culture of its people and how it affects the overall running of the company. This ‘cultural’ approach has been one that has been largely ignored within the AEC sector, possibly due to the diverse and fragmented nature of the construction process as well the hierarchical structure that it historically operates under whereby certain roles are guarded with an uncompromising attitude. This attitude is very prevalent among architects who, for some reason are unwilling or maybe unable to communicate their design ideas to the actual trades doing the work.

#### ***4. Aims and Objectives***

- Identify the available technology and what it is capable of doing to enhance the construction management process.
- In order to address the issue of human culture within the AEC industry we must look at it from a historical as well as a modern point of view.
- Consider the obstacles to implementation of ICT into a construction company whether they are cost issues or general lack foresight on the part of the contractor.
- Explore the benefits for all involved in terms of a smoother work flow, safer working environment, reduction in waste while achieving a sustainably built environment.
- Finally we shall see if ICT can work for small contractors and sub contractors alike.

## ***5. Possible solutions***

There are currently various devices available such as smart phones and tablets which can aid in the sharing of information between the design team, contractor and trades. Software vendors are constantly developing applications for these devices and with the ever increasing availability of 3G and 4G connectivity, even remotely located sites can avail of the technology. Having said that, serious consideration must be given to the exact requirements of the contractor and the type of projects that they are usually associated with prior to any decision being taken as to the type of system that may be required in order to implement an effective ICT policy at site level. Firstly, the system should be sufficiently advanced as to meet the requirements of the site manager and engineer in terms of: (1) speed of communication, (2) clear visualisation and (3) quantity of information.

Real-time communication of data between the design team, head office and site management is essential to ensure the actual construction process runs as efficiently as possible thereby eliminating the need for RFIs which can be a major source of delay and cost overrun on a project. On large sites, when using Wi-Fi, there can be problems with connectivity between mobile devices and fixed computers in the site office, therefore the use of wireless networks is essential to overcome this issue and ensure real time collaboration. To deal with buildability issues that often arise at construction phase, there is a need for clear visualisation of design details, especially in 3D format, as it can be difficult for trades to interpret the architects ideas based on 2D drawings and specifications. Smartphones or tablets can be used for the visualisation of these design details in that any part of the design can be inspected closely by zooming in on the screen. The sheer quantity of information required for the construction process can lead to the accumulation of large volumes of paperwork at the site office with the inherent risk of loss of details; therefore the introduction of ICT at site level should reduce this volume of paperwork by having everything stored electronically.

The next issue to be considered is the choice of application software required for the construction project and this will very much depend on the scale of the projects usually undertaken by the contractor. All projects will require the use of applications such as Microsoft Word, Excel, Project and Adobe Reader for the management of information on site such as, sub-contractor information, construction methods, health and safety files and works progress logs. While large projects may require access to a full suite of BIM software, which may be stored on a remote server and accessed as required by site managers and engineers,

small contractors may only have need for a CAD drawing viewer installed on their tablet computer, such as Autodesk True View which is a free programme that allows users to open and view DWG files.

As stated earlier the choice of which types of mobile computing device to use will depend on the requirements of each contractor however all these devices need to have; multiple data transfer methods such as USB ports, Bluetooth and Wi-Fi and should have sufficient screen size for display of CAD drawings. Consideration must also be given to the robustness of any device chosen to ensure that it is capable of dealing with the actual environmental conditions that occur on a construction site, in terms of dust, moisture and noise. Other essentials that mobile devices must contain are, touch screen, keyboard, camera, microphone, speakers and battery life that will last for at least an eight hour working day. These devices must also contain GPS capabilities to ensure the user is in the correct location when recording information required for submission to head office in order to apply for stage payments.

## **6. Culture**

Staff training is a key issue when it comes to implementing new ICT processes into an organisation. Companies need to see the merits of investing in training for its people in order to ensure they are up to date with the technology and work practices required for modern construction processes. This brings us back to the 'culture' within the AEC industry and its resistance to change. If we are to understand how to make the AEC industry more efficient and productive then we must better understand the role that culture plays within the industry (Shein, 1997). Only when we begin to understand the role culture plays within an organisation are we in a position where we can effect change. However, this change takes time as people in general are very resistant to change their commonly held attitudes, values and beliefs (Williams, 1993).

In order to effect change, we must convince organisations and the people within them of the actual 'need' for change. Alas this is easier said than done as people are 'blinded' by the '*way we have always done things around here*'. People need to be motivated to change whether that motivation comes from a real or perceived threat to their job security. However, this may only result in short term behavioural change as people are creatures of habit and

often revert back to the way they are used of doing things. Real change must begin at management level with key figures showing their willingness to adapt to new practices, thereby demonstrating to others within the organisation that change is not a bad thing and can be embraced. To reinforce this willingness to change, these key persons must communicate openly to all employees the benefits of such change to them, as well as to the organisation which they are a part of.

One key area that cannot be ignored when trying to effect change is the one of ‘respect’ that upper management have for lower level employees. Historically, within the construction industry, trades persons were held in high esteem for their skills and knowledge; however this respect has diminished to a large extent in modern times, to the degree that there is now a large disconnect between these trades persons and designers and/or management. This disconnect not only affects morale it also has the consequence of the organisation being unable to hold on to good people which will in turn lead to lower outputs and reduced profits for the company. Companies who continuously fail to respect all their employees will eventually be unable to recruit or retain talented people (Rethinking Construction, 2000). Unless there is a culture of mutual respect engrained within an organisation, then real change will be very difficult, if not impossible to achieve.

## ***7. Implementation costs***

The costs associated with implementing an ICT system into a construction company will depend entirely on the nature and scope of their business model and while it may be difficult to quantify in terms of Return On Investment (ROI), it is widely accepted among those that have invested in technology and people, that these costs were worth it. While the benefits of implementation of ICT at site management level can be difficult to quantify in terms of bottom line profit for the organisation, any system that improves the construction process in terms of cost, quality, time and client satisfaction has to have a positive effect on profits. In order to convince upper management of the need to invest in ICT at site level, site managers and engineers need to be able to demonstrate their willingness to adopt and use this technology effectively thereby assuring that the investment can be seen to be worthwhile.

## ***8. Benefits gained***

As already stated the benefits of implementing an ICT policy at site level can have the effect of greater productivity, better time management, improved quality as well as reduction in costs, thereby ensuring client satisfaction.

Better communication and collaboration between all involved in the construction process will inevitably lead to a smoother workflow with resulting efficiencies in production. Other benefits that are possible include: a reduction in construction time and therefore cost, reduced rework due to defects, reduction of waste and a reduction of accidents. An added benefit of utilising mobile computing devices on site is that, as-built information can be recorded for the client if there has been changes to the original design.

## ***9. Opportunity for SMEs***

Due to the appalling lack of proper Building Control in Ireland in the past, there is now being introduced, new legislation which is hoped will address the issue of compliance with Building Regulations. To this end, at design stage, construction details and specifications must be inspected and signed off, by suitably qualified certifying professionals. These same professionals must also now inspect the works as they are proceeding, in order to ensure that the actual building is being built as per the design.

It is envisaged that there will not be enough of these professionals to adequately carry out these inspections which would entail multiple site visits, resulting in extra costs to the client. This scenario poses an opportunity for the Small to Medium Enterprises (SMEs) to be introduced to the use of mobile computing devices to record works progress. Photographs and videos could be taken of the actual work done at any given time on the construction site and sent electronically to the certifying professional as proof of compliance with the building regulations. As smartphones and tablets have GPS capabilities built-in, the coordinates of the works could be embedded in the images as proof that they were taken at the actual project. This simple process would, (1) Familiarise contractors and subcontractors with the technology, making them more likely to adopt it for more general construction management processes and, (2) eliminate the majority of site visits that would otherwise have to be done by the certifying professional, which in turn would reduce costs to the client.

## ***10. Case Study***

An study into the usefulness of mobile computing devices was undertaken between 2005 and 2007 by the Swedish construction company, Skanska, who are one of the largest building and engineering firms in the world. The pilot project for this study was a construction project at Duke University in North Carolina. The site management staff were looking into ways to improve their handling of construction site work activities and one idea was to see if the ICT process could be expanded onto the actual jobsite. The issue on this project as with most construction works was that the vast quantities of information that needed to be passed to the site led to poor quality information in the field. As a result the project team developed software and used existing tools that would provide site personnel with the same quality of plans and specifications that were available to the project management team.

Tablet computers were the natural choice for this process as the latest plans and specifications could be wirelessly synchronised at any time for use by site personnel. Once the new system was introduced, a user champion was identified to support its development. The champion, with the support and encouragement of the other members of the team began by replacing some of its own work routines with those possible using the new mobile computing tools. As the project developed so did the tools that were required to meet them and as a result, existing administrative on-site work processes were replaced with ICT tools.

When equipped with updated project information on tablet computers, the site management team experienced improvements in their own personal productivity which meant that they were able to respond to more issues, in more detail, and in real time, thus preventing construction rework. This speedy resolution of issues allowed construction workers to maintain productivity and ensure quality standards were achieved.

As a result of the tablet computer pilot project at Duke University, a global mobile computing effort within the company was initiated and a coordinator was appointed to encourage the use of tablet computer technology worldwide at Skanska's construction projects.

## ***11. Case discussion***

The implementation of the tablet computer process at Skanska's operations has shown that the role of people and their interaction with technology is crucial to the development of ICT systems at site level. The appointment of a user champion who could explore the technology, figure out the best use of tablets and explain the benefits to management was essential part of the project. This user champion creates the vital link between construction workers, site management and upper management, where better communication and collaboration can be achieved thereby bridging the cultural issues and resistance to change that are often present in the construction site environment.

Although this study was undertaken by a multinational construction company, there is no reason to believe that the same processes could not work for any size construction operation especially considering the widespread availability of devices and technology that exists today.

## ***12. Conclusions***

The AEC industry is a diverse and fragmented one with many different disciplines working within their own agenda which lends itself to a perpetuation of this fragmented nature with the inevitable result of a breakdown in communication at all levels. This is particularly the case here in Ireland where there is a large disconnect within the construction industry between the so called blue collar and white collar workers. This disconnect is imbedded in the Irish culture, probably due to historical reason to do with colonisation and therefore one that is not easily remedied. In order for it to change, the professional classes will need to change their attitude of superiority towards ordinary workers and these same ordinary workers will need to lose their resentment towards anyone that is more educated than them. Alas, this is an age old Irish issue and one for cultural historians to analyse and comment on.

On a brighter note, as seen in the case study, when the right people are given the opportunity and support to facilitate change then this change can occur, with resulting benefits to all involved in the construction industry.

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