

Computing Technology Usage in Construction Contractor Organizations

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Abstract

Computing technology in the construction industry can be broken down into automation and information and communications technology (ICT). Construction automation entails the use of computers to replace and/or enhance a variety of jobsite applications including surveying, the control of equipment, and the installation of prefabricated units using Global Positioning System (GPS) technologies and advanced robotic systems. Construction ICT entails the use of computer systems that are capable of capturing, organizing, storing, analyzing, exchanging, transmitting, and sharing information. Automation and ICT have previously been recognized as tools for increasing competitive advantage in the construction industry, however, this industry has been slow to adopt these technologies especially when compared to the manufacturing and service industries. The construction industry has undergone changes in recent years which have resulted in many construction organizations attempting to implement some form of automation and/or ICT. Currently, the construction industry is characterized by the rapid development of jobsite automation technologies which has resulted in a large amount of real-time data being produced in the field. This data is oftentimes not recorded and not converted into meaningful information. As a result, the industry has yet to experience the full benefits of using computing technology in construction. This paper will discuss how a construction contractor can increase his competitive advantage by integrating the real-time data collected from jobsite automation with ICT technologies thereby creating a total jobsite management tool.

Keywords

Automation, Construction, GPS, ICT, Real-Time Data

1. Introduction

Computing technology in the construction industry can be broken down into automation and information and communications technology (ICT). Construction automation entails the use of computers to replace and/or enhance a variety of jobsite applications including surveying, the control of equipment, and the installation of prefabricated units using Global Positioning System (GPS) technologies and advanced robotic systems. Construction ICT entails the use of computer systems that are capable of capturing, organizing, storing, analyzing, exchanging, transmitting, and sharing information. Examples of ICT

include video conferencing, web-based project management applications, database management systems (DBS), data warehousing (DW), and data mining (DM). The focus of this paper is the use of real-time data collected from on-site automaton applications integrated with ICT components for management and decision making purposes.

2. Potential Benefits

The potential benefits of implementing automation and ICT in the construction industry are summarized in Table 1 below (Leslie & McKay, 1993; Warszawski, 1990).

Table 1 – Potential Benefits of Automation & ICT in the Construction Industry

Automation	ICT
Savings in manual labor costs	Communicate performance requirements and flag subsequent action needed by others
Shorter construction duration as a result of higher productivity	Coordinate with other team members in making decisions
Determination of optimal combination of machines	Monitor decisions and actions to ensure that interim conditions for meeting all of the project's performance goals will prevail
Use of machines in places where the tasks are repetitive or dangerous for the workers	Check for a certified compliance with stated performance requirements

Although automation and ICT are recognized as tools for increasing competitive advantage in the construction industry (Beliveau, 1996; ENR, 1999; Gibson & Bell, 1992; Jung & Gibson, 1999; Tucker & Haas, 1999) the construction industry has been slow to adopt these technologies. If and when these technologies are adopted they are often done so independently of one another and have not been successfully integrated to work together in the construction environment.

3. The Challenging Construction Industry

The stated benefits of automation and ICT (Table 1) appear to be substantial; however the construction industry has been slow to adopt these technologies especially when compared to other industries such as the manufacturing and service industries. The manufacturing industry has seen significant increases in productivity and quality by implementing automation technologies (Jung & Gibson, 1999; Warszawski, 1990). Similarly, the service industries have reported increased customer satisfaction, financial performance, and productivity by incorporating ICT technologies into their business practices (Mulligan & Gordon, 2002; Zhu et al, 2002). The construction industry is unique in that it would benefit from the integration of automation and ICT technologies to improve construction performance. Since the manufacturing industry has had success using automation technology and the service industries have had success in using ICT technologies a comparison between these industries and the construction industry as discussed in the following sections will prove valuable.

3.1 Manufacturing versus Construction

The manufacturing industry has seen significant increases in productivity and quality from real-time automated data collection for process control and from the use of robotics to automate production processes. If the manufacturing industry is seeing so much success in the implementation of automation technologies why has the construction industry been slow to adopt these technologies? The answer can be found when the characteristics unique to the construction industry are examined. Warszawski (1990) summarized these differences and cites these differences as the reason why the construction industry has been slow to adopt automation technology (Table 2).

Table 2 – Main Differences between Construction Manufacturing Industries (Waszawski 1990)

Manufacturing	Construction
All the work performed in one permanent location	Work dispersed among many temporary locations
Short to medium service life of a typical product	Long service life of a typical project
High degree of repetition and standardization	Small extent of standardization; each project has distinct features
Small number of simplified tasks necessary to produce a typical product	Large number of tasks requiring a high degree of manual skills necessary to complete a typical project
All tasks performed at static workstations	Each task performed over a large work area with workers moving from one place to another
Workplace carefully adjusted to human needs	Rugged and harsh work environments
Comparatively stable workforce	High turnover of workers
Unified decision-making authority for design, production, and marketing	Authority divided among sponsor, designers, local government, contractor, and subcontractors

However, these differences do not indicate that the construction industry cannot benefit from automation technologies. It simply means that modifications to the techniques employed in manufacturing will be required prior to their implementation in construction. For example, the construction industry can benefit from manufacturing principles by the using real-time automated data collection for project controls and by the use of robotics onsite for building component installation. In addition, the single family housing industry can benefit by using prefabricated building components produced in manufacturing plants offsite.

3.2 Service versus Construction

In the construction industry, success is not only measured by the final product (building, highway, etc) but also by the customer's perceived level of service. With this in mind, the construction industry is perhaps more closely aligned with the service industry rather than the manufacturing industry that it is so

often compared to. The U.S. Standard Industry Classification System does not classify the construction industry as a service industry; however, the two industries are both customer satisfaction driven where the relationship between the customer and supplier is critical to success. In addition, both the construction and service industries work under relatively small profit margins and rely on cost control measures to achieve success. The service industries have been very successful in leveraging ICT technologies to achieve increased customer satisfaction, financial performance, and productivity. The use of ICT in service industries is unprecedented compared to other industries where many industries such as the banking and airline industries are almost totally automated. As such, the construction industry can benefit from taking a close look at the success factors for ICT implementation in the service industries and how these factors can be modified for use by construction contractor organizations.

4. The Current State of Automation & ICT in Construction

Although the uniqueness of the construction industry has posed challenges to the implementation of automation and ICT technologies there are several factors indicating that the nature of the construction industry is changing. These factors include (ENR 1999; Poppy 1994; Waszwaski 1990):

- An extensive lack of skilled workers and a growing average age of the staff;
- An inability to attract and retain talented, educated personnel;
- Increased industry competition;
- A need for works in dangerous and inaccessible areas of operation;
- Increased requirements on the quality of the work execution; and
- An increase in performance and reduction in costs is required to maintain a competitive advantage.

In addition to the above listed industry changes, owner organizations are beginning to demand access to real-time data for their own automated site inspections and these owners expect this access to be available at all times. This has put increased pressure on contractor organizations to embrace new technologies in order to remain competitive and satisfy these changing owner demands.

As a result of the changing nature of the construction industry, many construction organizations have already begun implementing some form of automation and/or ICT or are considering doing so in the near future. For example, major construction contractors Cherry Hill Construction, Taylor Construction, and McAnich Corporation have reported significant benefits in the use of on-site automation technologies. Now that these and other firms are having success in the use of on-site automation they are considering expanding their technology programs to include ICT technologies which will utilize real-time data collected onsite to improve management and decision making functions (Hampton, 2005). A construction contractor can increase his competitive advantage by integrating the automation and ICT technologies thereby creating a total jobsite management tool capable of analyzing the construction project in the areas of: 1) project performance control, 2) materials and equipment management, and 3) human resource management. Some of the potential advantages of integrating automation and ICT for use as a total jobsite management tool may include:

- Real-time monitoring and documenting of construction operations,
- Reduced paperwork,
- Improved project management capabilities in terms of tracking people, equipment, and assets,
- Early detection and fast response time to problems,
- Standardization of data collection and management,
- More accurate performance data which can be used for planning of future projects,
- Creation of a history or baseline for dispute resolution, and
- Reduced contractor reporting requirements because the owner/engineer can continuously “see” what is happening onsite.

Furthermore, Hampton (2005) describes the current state of computing technology in the construction industry by stating that the industry is currently data-rich but not information-rich. In other words, the rapid development of on-site automation technologies has resulted in a large amount of data in the field, however traditional manual processes are still being applied for management and decision making purposes. The data being produced in the field is oftentimes not recorded (Ligier, 2001) and not converted into meaningful information. As a result, the industry has yet to experience the full benefits of using computing technology in construction.

5. Research Needs

A study is currently underway at Florida International University in Miami, Florida aimed at investigating the potential impacts of integrating automation and ICT for use as a total jobsite management tool and to assess implementation requirements for construction contractor organizations. This research is being conducted through the following objectives.

Objective #1: To identify the current and potential applications of automation and ICT by construction contractor organizations. The following list of questions will be answered:

- What types of on-site automation (such as GPS) are construction contractors currently using and what are their applications?
- How is this technology impacting construction contractors in terms of productivity, cost, etc.?
- If contractors are not implementing these technologies, why?
- Is the on-site data integrated with ICT for use as a total jobsite management tool or is the technology used solely for isolated activities?
- How do contractor organizations currently store and organize data (manually or electronically)? If the data is stored and organized electronically what software(s) are used?
- What functions (project performance controls, equipment and materials tracking, and human resource administration) are currently managed using real-time data.
- What can be learned from the success seen in the manufacturing and service industries that can be modified for application in construction?

Objective #2: To assess the impacts and develop an implementation framework for the integration of automation and ICT for use as a total jobsite management tool. A major portion of this framework will involve identifying the optimum alignment of computing technology, used as a total jobsite management tool, with the construction contractors' organizational structure and business processes.

6. Conclusions

The integration of automation and ICT in construction has the ability to revolutionize the way contractors do business by increasing productivity and at the same time reducing cost. However, preliminary research has indicated that construction contractor organizations are hesitant to implement new technologies perhaps due to the lack of a clear analysis of their potential impacts and a methodology for planning and implementation of these technologies. A clear theoretical framework is required to guide construction contractor organizations in the selection and implementation of appropriate computing technologies that fit the requirements of their business processes. This framework is currently under development at Florida International University.

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