# CONCEPTUAL MODEL OF RFID APPLICATION IN PREFABRICATION INSTALLATION PROCESS

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## Abstract

Attempts to achieve a higher productivity have led studies to focus on process improvement. Information has been found as an essential element for process improvement. This research has introduced and focused on two types of information, namely: related jobsite information along the process and feedback information. Related jobsite information along the process which needs to be processed and delivered in a timely manner, accurate, and real time is required to streamline the decision making process. Whereas feedback information about process' current practices which have to be captured and stored is a useful for continuous improvement in identifying the problem origin and determining corrective action. In the current practices, although these two types of information are essential for process improvement, construction process has faced barriers in obtaining that information.

Therefore, this research will propose a new information system to overcome the aforementioned barriers. The new information system consists of RFID as an automatic identification and data collection device integrated with database to support construction processes. The new system attempts to provide related jobsite information along the process and feedback information to support decision making process and continuous process improvement respectively. A case study of prefabrication installation process in housing projects has been selected to be implemented in conceptual model of RFID application in construction industry. Conceptual model will be presented in this paper as an initial stage of this ongoing research. Expected outcomes of the new system and future works will be discussed briefly.

**Keywords:** Process improvement, Field-data collection, RFID, Prefabrication

## 1. Characteristics of Process Improvement

Although productivity is fundamentally an output to input relationship, the productivity can be improved not only by looking at the numerator and denominator but also by investigating the throughput process itself. A higher productivity can be achieved by looking into the process, evaluating the current process to gain feedback and conducting a continuous process improvement. This suggestion is endorsed by [1], which noted the need to focus on the process for quality and productivity improvement (cost and speed) stems from fact that, improvement will come only by good control of the process and resources. Similarly, [2] and

[3] revealed the need to focus on efficiency of the construction process management to enhance productivity. Thus, process becomes the key in achieving higher productivity. In other words, process improvement is a method of productivity improvement since it can improve the information flow, minimize waste of labor hour, and reduce productivity loss.

[4] suggested that process improvement can be carried out by three main approaches: systems, management, and work tasks. Although these three approaches benefit to identify the issues and problems occur in construction processes, they require basic information for their analysis. First, benchmarking is one of techniques in the systems approach. It requires information of performance records from previous or other projects to compare their performance. Second, worker survey which is a part of management approach, needs information about current practice to identify work's constraints. Third, work measurement which is a part of work task approach, requires information about time record in executing tasks. All of this information has been perceived as feedback information. [5] stated that this type of information is useful for continuous process improvements in identifying the problem origin and determining corrective action. Beside the feedback information, the other essential information for process improvement is related jobsite information along the process. It needs to be processed and delivered in a timely manner, accurate, and real time updated to streamline the decision making process. Therefore, both types of information are becoming more important in producing a construction product and improving the construction process. Figure 1 illustrates the flow of both types of information (feedback and related jobsite information).

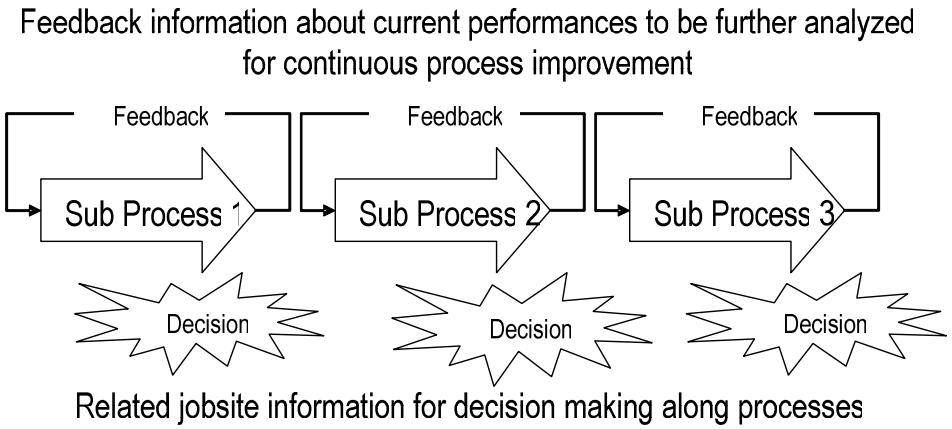


**Figure 1: Two types of information for process improvement**

## 2. Needs of Information for Process Improvement

Prior research in construction industry has endorsed that information becomes a critical factor for success in construction process improvement. According to [6], information has a great value if it is delivered in appropriate and accurate ways to the right people and place within the right time. Adrian described that management of construction needs more accurate and timely record keeping [7]. Even though the amount of information required producing a product is essentially the same today as it was in the past but at present time each new producing phase has required faster information processing time [6]. Efforts in obtaining and

providing these types of information are facing many obstacles which become the causes of the lack of information in many construction processes and finally impede their performances. The following section will discuss about the obstacles in obtaining and providing for both related jobsite and feedback information.

Time consuming tasks in capturing and storing information about the processes, become barriers of process improvements. For example, in acquiring time records of the installation prefabrication components, extra workers are required to record the process and complete specific forms manually. In addition, manually-recorded information is collected as data is required to re-entry into electronic formats for further analysis.

Based on the above constraints, information technology (IT) can be used to support process management by reducing tedious, time consuming, and inaccurate project paper works that characterizes the construction process [7]. In addition, IT encourages processes by providing current information in timely manner, enhancing communication between parties involved in the project, and enabling new approaches in doing processes.

## 3. The Assistance of Information Technologies

Several reasons have been exist and impeded the construction processes in terms of the lack of information. Previous study has discussed and addressed these reasons as follows [8]:

1. The lack of simple reporting methods and clear communication procedures.
2. The lack of fast feedback systems toward "fast-track" projects.
3. Time consuming tasks in obtaining field data and writing reports that all detract from the attention that could be devoted to actually managing the project.

These reasons arise from the needs of information that construction processes require related jobsite information which has to be imparted in accurate way, a timely manner, and updated to commence the works and in decision making process. Along with that information, information of construction process' current practices is also required as feedback information for further analysis in process improvement. Currently, the availability and time consuming tasks in capturing and storing this type of information become barriers in improving construction process.

Construction industry as well as the other industries has observed on technologies (information technologies) as promising solution to overcome information barriers. Information technologies (ITs), by providing faster feedback and accurate information and supporting for remote and concurrent decision making, offered the possibility to improve construction process. The abilities of ITs to overcome construction industry's constraints in terms of information have been proved and had constructive impact to the construction industry. Gann noted that information technology (IT) has major impact on the construction industry, which leads to an augmentation in productivity by [6]:

- Reduce tedious, time-consuming, and inaccurate project paper work.
- Enable collection of new information that should enable improved measurement of productivity e.g., corrections can be made and benchmarking can be performed.
- Improve communication and information transfer.

Therefore, the assistance of ITs is required to support construction process improvement by streamlining decision making process and providing feedback information towards process improvement.

ITs open a new way in collecting and utilizing jobsite information. These features aim to answer the needs of more accurate and timely record keeping which are required by construction management. Time to do the necessary paper work takes away from the time to do construction work. Thus it needs technologies to help them such as barcode, digital cameras, fully integrated estimating and control systems, equipment guided by lasers and global positioning satellites, and internet-based technology to provide new ways to collect and utilize jobsite information [7]. This information can be applied to improve productivity with automation and integration in processes.

An automatic identification system consists of a technology for automatically gathering information and a computer database system to manipulate the information [9]. This research presents one form of automation and integration in identifying objects, collecting data, record keeping, and real time jobsite status. These systems include a means to automatically identify, track, locate, or status document, some individual or transaction item, and enter this information into a computer database. In this research, RFID as one of automatic identification technologies is selected to be used as a technology for data acquisition regarding to its abilities over the other automatic identification devices.

## 4. Objective of the Research

This research aims to apply RFID as one of the latest ITs in automatic identification for construction process improvement. The research uses prefabrication installation process in housing projects as a case study. The main reason behind the selection of this case study is the usage of discrete parts in the form of prefab components (panels). In prefabrication (prefab) construction method, the building structure is divided into parts (panels) which allow the RFID tag to be attached onto panels whenever they are manufactured. Related information that can help to streamline the processes can be embedded into tags. This will enable the integration of information from design to installation stage. Using the same analogy with the application of barcode on retail industry, the attachment of RFID tag onto component (panel) will help to do automatic identification, data collection and monitoring the jobsite latest status. The new information system so called RFID system consists of RFID integrated with database. RFID system is utilized in obtaining feedback information and providing related jobsite information that can be used for process improvement.

## 5. Methodology of the Research

This research will be conducted through the several steps. It started from reviewing literatures related to prefabrication, process improvement, and ITs application in construction industry. Then, together with literature review, field observation is conducted as a preliminary study. Conceptual model of how RFID system works in this case study is developed based on

preliminary study and the results of data collection. The conceptual model then will be realized by designing and generating RFID system. At first, the generated RFID system will be simulated off site to see the initial performance and gain feedback for improvement to the system. Then, RFID system will be tested onto construction site and adjustment to the system will be done. RFID system's performance will be observed and analyzed to produce constructive feedback to the system. Finally, more possible benefits of applying and developing these new systems are explored. This paper will mainly discuss about the conceptual model of how RFID works in supporting prefabrication installation process in housing projects.

## 6. RFID Application in The Case Study of Prefabrication Installation Process in Housing Projects

The applications of prefabrication (prefab) construction method have recently increased in many construction projects. Several reasons have encouraged the prefabrication usage. They are the increasing in the needs for all types of building particularly housing, limited available space for construction site, rising requirements in maintaining and/or achieving quality, and the need to provide affordable price of buildings which can be derived from the large production of standardize components.

Prefabrication refers to the production of components under factory conditions, and their assembly on site [10]. The use of prefabrication construction method aims to reduce costs, increase speed of construction processes, and improve quality [10]. Prefabricated structural components made of concrete are referred to as "precast units", signifying that they are cast in advance and given time to harden and acquire strength before being taken to the actual construction site for assembly [11]. Comparing to cast-in-place construction method, prefabrication offers at least five distinct advantages which are improved quality with better quality controls, reduction in wastage, less labor intensive operations, faster production of building components, and economies of large-scale production [12]. Although prefabrication method promised many benefits which are mentioned above, construction industry has not yet achieved all those. The limitations occur when prefabrication components have been transported to and assembled on construction site.

Various researches have been conducted essentially to explore how to improve the installation of prefabrication components on site as a quest to overcome the above limitations. Based on prior research, several ideas are proposed to improve the productivity of prefabrication installation. Firstly, [6] observed the development of better designs, materials and components. This helps to improve construction processes, focusing on minimizing on-site work and improving the accuracy, speed, and quality of construction. Secondly, [5] pointed out that quality control has to be exercised towards productivity improvement in all activities such as designing, construction, manufacture/production of concrete constituent materials, and production of prefab concrete elements/components. Finally, [2] and [3] revealed the need to focus on efficiency of the construction process management to enhance productivity.

As discussed in the early section of this paper before, process becomes the key in achieving a higher productivity. Efforts to improve the process require two types of information which are related jobsite information along the process and feedback information. Similar with the other processes in construction industry, prefabrication installation process also requires both types of information to streamline its process. Prefab installation process has seen information technologies (ITs) as a strong solution in responding the needs from both types of information. ITs is capable to deliver related jobsite information in accurate way, a timely manner, and updated to commence the works and in decision making process. In addition, ITs assist in providing feedback information and saving time to capture and store this type of information. In this research, RFID as the latest ITs in automatic identification and data collection will be integrated with several IT applications (database, 3D, and communication) to support prefab installation process.

### 6.1 Automation and Integration with RFID

RFID (as shown in Figure 2.) which use radio waves instead of light waves to read a tag can be viewed as a next generation technology to bar code labels and the system typically comprises of the following components:

- Reader that communicates with or interrogates the tag for reading and writing by using at minimum, an antenna and scanner. Readers can be either fixed-position or portable [13, 14, and 15].
- A tag or label that is embedded with a small integrated circuit chip and an antenna which are encapsulated in protective shell [13, 14, and 15]. [15] pointed out that an RFID system can read the information on a tag without requiring line of sight or a particular orientation. This means that RFID systems can be largely automated, reducing the necessity of manual scanning for exceptions management.

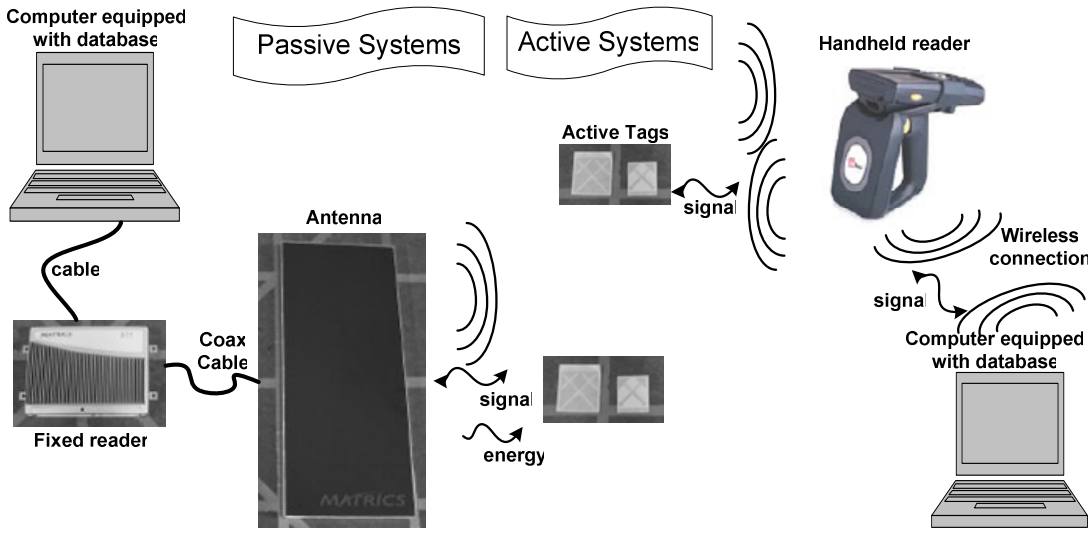


**Figure 2: How current RFID technology works**

Comparing with the other automatic identification technologies, RFID offers advantages over its kind. [15] described that RFID is a flexible technology that is convenient, easy to use and

well suited for automatic operation. It combines advantages not available with other identification technologies: RFID does not require contact or line-of-sight between the reader and the object to be identified; can function in harsh environments; enables multiple tags to be read simultaneously; and provides a high level of data integrity.

## 6.2 Conceptual model of RFID works in this case study

This conceptual model of RFID works in this case study aims to describe one from many applications of RFID in construction industry. A new information system comprise of the use of radio frequency identification (RFID) as an automated identification tool integrated with database is proposed in this paper. Within this case study, the RFID system will be implemented into two phases which are found and defined (as shown in Figure 3.). First phase is stretched along the manufacture to prefab stockyard whereas the second is stretched along prefab stockyard to installation point. This system automatically identifies prefabrication (prefab) panels, collects and records their related data (work sequences, panels handling, and installation time) into database, and monitoring the latest status (real time) of jobsite performances.

This new system aims to support prefab installation process by providing related jobsite information to enhance decision making process and feedback information which can be used for further analysis of process improvement. Both types of information are very valuable to streamline the process.

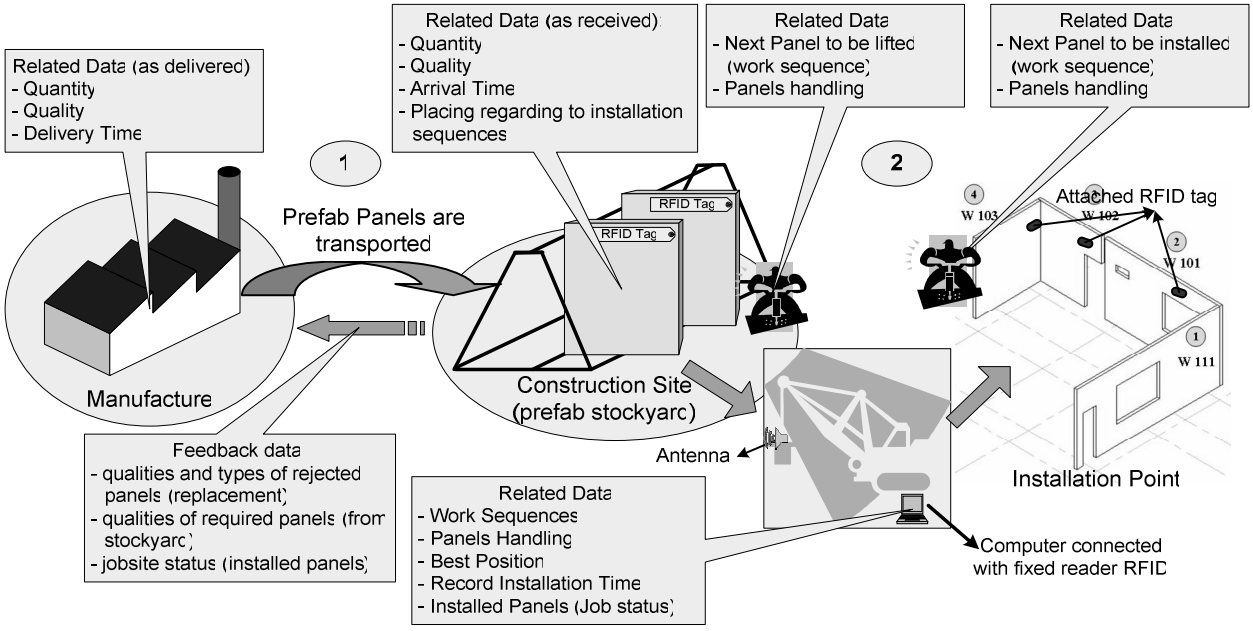


**Figure 3: Conceptual model of RFID works in this case study and related information**

### 6.2.1 Manufacture – Prefab Stockyard

The above figure describes about how RFID system can support the delivery process. RFID tags can be attached as soon as panels are produced. The attached RFID tag contains information that related to jobsite information. For example: panel's information regarding to the installation, the quality as it departs from manufacture, and delivery time. These details of information can be represented by direct information that embedded into tags or by codes as identification (ID) number that associated to some information which can be retrieved from database. When prefab panels arrive on construction site, data which related to the arrival can be uploaded to the database directly. The RFID readers which can be in fixed (in form of portal) and portable reader (hand held form) will interrogate (identify) the received panels and collect their data. Information related to the quality, quantity, and arrival time will be added into database. The storage of prefab panels is arranged based on their associated location regarding to its installation sequences. This kind of information can be retrieved from database when RFID system identifies panels. In the case of damaged and rejected panels, the status of quality (accepted, rejected, and damaged) and its ID number can be uploaded to the database. The quantities of installed, damaged and rejected panels are reported as feedback to the manufacture and the report can be useful in making decision for associated party. In the case of damaged panels, authorize parties are helped in making decision upon the damaged panels whether can be repaired or have to be replaced. Manufacture use the report to send the new panels and replacement before installation time which will eliminate delays since panels are available and ready to be installed. The information can be delivered and processed in a short time by using integrated database. By comparing the information related to quality, quantity, and timing between delivery and arrival, the related problems occur along these stages can be identified and further analyzed to improve the process.

### 6.2.2 Prefab Stockyard – Installation Point

The application of RFID in prefab installation process aims to support the process by obtaining feedback information and providing related jobsite information. It starts when crane will lift up the selected panel regarding to its sequence. Foreman by using handheld reader retrieve data from database about which panel that next have to be lifted and how to handle the panel lifting. Equipped with this information, foreman can arrange and instruct labor to prepare and execute the work. Meanwhile, the crane operator can retrieve information related to work sequence (next panel to be lifted), panel handling (lifting phase), and best position to do lifting. The new information system will inform the next panel to be lifted and tracking the associated panel. The crane operator can move the boom which is equipped by RFID antenna to scan through panels and stop at the place when system found the correct panel. At the same time, foreman at installation site by using handheld reader retrieve information from database related to work sequence and panels handling (installation phase). Based on this information, foreman can arrange and instruct labor to prepare and execute the work. Information related to work sequences and panels handling is presented in 3D form. Assisted with labor which have prepared near the correct panel, crane lifts the panel onto installation site where labor have prepared to do the installation. Crane operator can record the installation time start from lifting and installing each panel by using this system. After finish installing current panel, crane

operator have to confirm so that system can collect data and generate reports about installed panel and installation time.

## 7. Summary and Future Works

This paper presents a conceptual model of RFID application as an approach to improve construction process in terms of information. The conceptual model of RFID application is proposed as a new information system to support prefab installation process and a part of on going research. This conceptual model of RFID application soon will be generated and tested as a future work. With RFID as an automatic identification device, an integrated database will be designed based on the information needs to support prefab installation process. The easiness and simplicity to understand and operate will be concerned in designing user interface.

By providing related jobsite information, the new information system (RFID) hopefully will streamline the decision making process with updated, timely and accurate jobsite information. By capturing and storing the current practices of prefab installation process for further analysis of feedback information, RFID application is hopefully can identify the problem origin and determine corrective action in prefab installation process for continuous process improvement.

RFID as a new information system is expected to support prefab installation process by providing both types of information to streamlining the process. As a result, the enhancement in the following ways will be investigated. It enhances planning, monitoring, coordination, data collection and record keeping of jobsite performance. Along with that, quality and quantity will be well controlled and knowledge transfer about prefab installation to craft level will be secure.

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