# USER NEEDS FOR RFID-CLOUD CONSTRUCTION EQUIPMENT MANAGEMENT SYSTEM

LEE TSU YIAN

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Faculty of Engineering
Universiti Teknologi Malaysia

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## DEDICATION

This thesis is dedicated to my parents for their support and patience and encouragement.

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## ABSTRACT

An effective construction equipment management system on construction site is significant to ensure that the equipment is always ready and safe for use. Site productivity is also influenced by the equipment management system effectiveness. To enhance effectiveness, this study takes the opportunity to propose a Radio Frequency Identification (RFID)-Cloud construction equipment management system. This study was first conducted using questionnaire survey with site staffs of case study. Then, all the respondents were interviewed to study their expression on questionnaire response and their needs for the construction equipment management system. The User Requirement Specifications (URS) and user interface (UI) prototype of the system were then developed based on the user needs by conducting user requirement study. The data collected from questionnaire was analysed by calculation of Relative Importance Index (RII), revealing the importance level of issues. As a result, six out of ten issues were found highly important. Respondents further elaborated that information keeping and tracking plays significant role in ensuring equipment management system effectiveness. It was claimed that proper record keeping can improve work efficiency by reducing time consumption on searching for information. For interview survey, four groups of user needs, which are equipment inventory information, equipment maintenance management, equipment status tracking and the other needs were sorted out using content analysis. The user needs identified were further translated to actionable design inputs in URS and UI of the RFID-cloud system. In URS, there were fourteen system modules designed and described. Cross-functional flowchart was mainly used as a tool to describe the workflow of all modules designed for the system. Meanwhile, UI display the design of the system modules described in the URS. In conclusion, the output of user requirement study contributes to the construction industry by introducing the concept of how equipment management practice on site can be transformed from conventional method to a digital RFID-cloud system.

# ABSTRAK

Sistem pengurusan peralatan pembinaan yang berkesan di tapak pembinaan adalah penting untuk memastikan bahawa peralatan sentiasa sedia dan selamat digunakan. Produktiviti tapak kerja juga dipengaruhi oleh keberkesanan sistem pengurusan peralatan. Kajian ini mencadangkan penggunaan teknologi Pengenalan Frekuensi Radio (RFID) dan Awan (cloud) untuk meningkatkan keberkesanan sistem pengurusan peralatan pembinaan. Kajian ini bermula dengan tinjauan soal selidik dengan kakitangan kajian lokasi. Kemudian, semua responden ditemu duga untuk mengkaji ekspresi mereka mengenai tindak balas soal selidik dan keperluan mereka untuk sistem pengurusan peralatan pembinaan. Prototaip Sistem Keperluan Pengguna (URS) dan antara muka pengguna (UI) kemudian dikembangkan berdasarkan keperluan pengguna dengan melakukan kajian keperluan pengguna. Data yang dikumpulkan dari soal selidik dianalisis dengan pengiraan Relative Importance Index (RII), yang menunjukkan tahap kepentingan isu. Hasilnya, enam daripada sepuluh isu didapati sangat penting. Responden seterusnya menjelaskan bahawa penyimpanan dan pengesanan maklumat memainkan peranan penting dalam memastikan keberkesanan sistem pengurusan peralatan. Diklaim bahawa penyimpanan rekod yang tepat dapat meningkatkan kecekapan kerja dengan mencepati proses mencari informasi. Untuk kajian melalui temu duga, didapati bahawa keperluan pengguna boleh dibahagi kepada empat kumpulan, iaitu maklumat inventori peralatan, pengurusan penyelenggaraan peralatan, pengesanan status peralatan dan keperluan lainnya melalui analisis kandungan. Keperluan pengguna yang dikenal pasti diterjemahkan ke reka bentuk sistem RFID-cloud yang dirancang dalam URS dan dipaparkan dalam UI. Dalam URS, terdapat empat belas modul sistem yang dirancang dan dijelaskan. Carta alir fungsi silang digunakan terutamanya sebagai alat untuk menerangkan aliran kerja semua modul sistem. Sementara itu, UI memaparkan reka bentuk modul sistem yang dijelaskan dalam URS. Sebagai kesimpulan, hasil kajian keperluan pengguna menyumbang kepada industri pembinaan dengan memperkenalkan konsep bagaimana amalan pengurusan peralatan di tapak pembinaan boleh diubah dari kaedah konvensional ke sistem digital RFID-cloud.

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| | | |
|---|---|---|
| GPS | - | Global Positioning System |
| IR 4.0 | - | Industrial Revolution 4.0 |
| PDA | - | Personal Digital Assistant |
| RFID | - | Radio Frequency Identification |
| URS | - | User Requirement Specification |
| UI | - | User Interface |

## LIST OF SYMBOLS

| | | |
|---|---|---|
| $\delta$ | - | Minimal error |
| $D, d$ | - | Diameter |
| $F$ | - | Force |
| $v$ | - | Velocity |
| $p$ | - | Pressure |
| $I$ | - | Moment of Inersia |
| $r$ | - | Radius |
| Re | - | Reynold Number |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Construction equipment is an indispensable resource in a construction project. Equipment on construction site varies from light equipment to heavy equipment, which can be differentiated based on the volume and weight of equipment. Equipment is designed specially to carry out certain job on construction site (Chitkara, 2009). Hence, many different types of equipment are employed on construction site to carry out different types of work. Since the usage of light and heavy equipment in construction project influences the work progress on site, it influences performance of project in terms of cost, time and quality (Day & Benjamin, 1989). Therefore, having proper equipment management in a construction project is necessary to ensure project success.

The discussion on the topic of equipment management by different sources such as books and journals often cover from the stage of equipment selection, equipment utilization until the disposal of equipment. Equipment selection is practiced at the initial stage of a construction project to decide types and quantity of equipment to use on site, based on plans, specifications, financial and other consideration (Chitkara, 2009). Then, when equipment is employed and utilised on construction site, the equipment management focuses on its usage, maintenance, safety, operations, security and cost-production records (Sasidhar *et al.*, 2017). Equipment may only be decided to be disposed of based on its condition and decision made by management level. Therefore, at the stage of equipment utilisation, proper planning and monitoring of the equipment management is significant on construction site.

In a project, different equipment is located at different position of construction site to carry out different task. Therefore, monitoring the equipment management work in a manual way may be difficult (Abas *et al.*, 2018). As a result, a lot of issues related to ineffective equipment management occur. Equipment management in other words is the management of equipment by people, which indicates that both management of equipment and workforce influence the effectiveness of construction equipment management system on construction site. Various issues related to equipment management should be prevented or solved to ensure that equipment is always ready for operation and safe for use (Razali & Manaf, 2007). An effective equipment management system should be able to perform proper monitoring of equipment maintenance, equipment operation, equipment inventory control and equipment security with systematic record keeping system, clear definition of roles and responsibilities and standardized information feedback system. An effective management system would have reduced issue occurrence, leading to better project productivity and performance. To improve effectiveness of management practice, transformation from conventional management method to digital system may be the solution (Kasim *et al.*, 2019).

In Malaysia, industries including construction industry are highly encouraged to practice the technology of Industrial Revolution 4.0 (IR 4.0) to solve different issues in industries to enhance competitiveness (Mottain, 2019). The main concept of IR 4.0 is the introduction of cyber-physical system in the industries, where the physical devices interconnected in a system are monitored by the computer entities in real time (Mottain, 2019). Cloud computing and Radio Frequency Identification (RFID) technologies are among the technologies of IR4.0. RFID technology can be used to tag each equipment with unique identity and track the real time information of equipment, while cloud storage can be used to store and allow access to the data over the internet (Owunwanne & Goel, 2010). When interfacing RFID technology with cloud computing, everyone accessible to the cloud can view data from RFID tracking, share data in the cloud and extract data from the cloud in real time on the internet (Owunwanne & Goel, 2010). It is believed that application of RFID and cloud technologies in construction equipment management can help to improve management workflow and reduce human error by enabling the site personnel to

track and access to the information of equipment management anytime and anywhere by connecting to internet.

## 1.2 Problem Background

In a construction project, different equipment would be purchased, rented or leased to conduct the construction works on site. They are considered as the assets on site that need to be handled, managed and stored properly to prevent losses. However, management of the equipment is not easy. A lot of problems can arise if a construction project is not having a proper equipment management system and the significant impacts are project delay and financial loss.

There are many factors affecting construction project delay and ineffective equipment management is one of them that should not be neglected. It was found that, among all the factors, equipment factor was grouped under the most significant group factor causing project delay (Aziz & Abdel-Hakam, 2016). An effective equipment management consists of management of both equipment and workforce who execute and monitor the system. Based on survey done by Sasidhar *et al.* (2017), the combination of manpower and machinery factors brings more than 50% impact on the project delay in residential building, commercial building and industrial building project as shown in Figure 1.1.

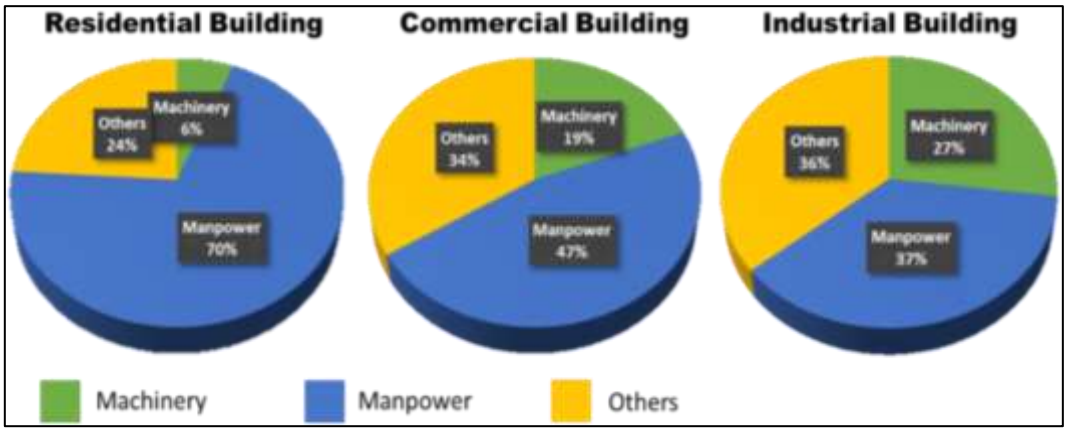


Figure 1.1 Factors causing project delay in residential building, commercial building, and industrial building (Sasidhar *et al.*, 2017)

Based on research done in Klang Valley, Malaysia, the highest average financial loss recorded due to loss of machinery on construction site was RM100,000 (Abas *et al.*, 2018). The types of machinery loss include compactor machine, drilling machine, mixer truck, excavator, backhoe and compressor machine (Abas *et al.*, 2018). It was found that theft and negligence are the causes of loss and it could be prevented by carrying out proper solution (Abas *et al.*, 2018). Even if management level is doing great job in planning work, it is found difficult to monitor the behaviour of every site personnel whether they complete their tasks such as conducting routine maintenance, recording equipment utilisation record and others (Shash and Ghazi, 2003). Hence, negligence of site personnel can lead to low project performance. In fact, RFID technology and cloud computing system which are real time technologies could be a proper solution for the issues. All equipment management information will be digitized, and information can be tracked in real-time. This makes monitoring works become easier.

## 1.3 Problem Statement

The negative impacts of ineffective equipment management system in construction project had been recognised. It was also realised that RFID and cloud computing are the helpful technologies for information tracking and management. However, no researcher has discussed the concept on how the construction equipment management system can be transformed from conventional management system to a digital system adopting RFID and cloud technologies. Therefore, this indicates a need to propose a RFID-cloud construction equipment management system.

## 1.4 Research Questions

This research believed that RFID-cloud construction equipment management would be more effective than the conventional manual management method. At the proposing stage, gap and limitation of current practice need to be explored prior to system design. Therefore, few research questions were formulated to narrow down the direction of the research:

1. What are the current issues faced by construction industry in equipment management?
2. What are the user needs for the RFID-cloud construction equipment management system?
3. What functions should be designed for the RFID-cloud construction equipment management system?

## 1.5 Research Objectives

The aim of the study was to design a RFID-cloud construction equipment management system based on user needs. The objectives of the study to achieve the aim were as follows:

1. To identify the current issues faced by construction industry in equipment management.
2. To discover the user needs for the construction equipment management system.
3. To design the user requirement specifications and user interface for the construction equipment management system.

## 1.6 Scope of Study

This research was an initial study for the equipment management system adopting RFID and cloud computing technology, where current issues of equipment management, user needs of effective equipment management and the functions of the proposed system were identified. This research focused on proposing the user requirement specifications and user interface of the proposed system that can be further used in the future research for complete system architecture development.

Case study method was used to achieve objectives in this research, where two construction sites were provided by a construction contractor company for data collection. The focus group in this research was mainly site personnel from main contractor because site personnel is the group of people that works exactly on construction site and most probably experienced the issues related to equipment management. Questionnaire survey and interview were conducted with all site personnel at the case study. The outcome of the interview was used for developing the user requirement specifications (URS) and user interface (UI) of the equipment management system.

There were some limitations of this research. Due to the interview was only carried out among workers of the case study, the system proposed was assumed to be suit with the circumstance of the case study only. In the context of equipment management, the scope of study only covered the management of equipment on construction site, excluding the equipment selection and deposition stage. This study also did not cover management of other resources such as materials and labour. However, future research to extend the scope of study is encouraged.

## 1.7 Significance of Study

Occurrence of different issues due to ineffective equipment management system has indicated that there is a need to have an effective equipment management system on construction site. In this research, the current issues faced by the industry in equipment management were identified. This is an important step before developing an effective equipment management system because it ensures that the developed system will be able to fill the gaps of the current existing system. Identifying the current issues related to equipment management also helps to stress the need of managing the equipment properly to contractor.

As an initiative to move into Industrial Revolution 4.0 (IR 4.0), this research proposes to handle this situation by using RFID and cloud computing technology. Besides able to monitor equipment operation and condition easily due to trackable feature added, the process of equipment management will be digitized. Digitalization of the process is expected to be able to improve the equipment management workflow on construction site in future because flow of information becomes better as compared practice of no recording at all or paperwork. As refer to objectives 2 and 3, user needs were identified and translated into design input. As a result, the final output of this research demonstrates how the user needs can be translated to an actionable design input of a RFID-cloud system. Besides, the industry practitioner will also gain idea on how the construction industry can be transformed from manual management method to digital system. The future research may also develop a real system and implement it in industry by referring to the findings from this research.

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