Research in Management of Technology and Business Vol. 3 No. 1 (2022) 431-444

RMTB

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rmtb
e-ISSN : 2773-5044

Radio Frequency Identification (RFID) Implementation for Human Tracking in Safety Management at Construction Site

Lim Jyy Chyi[1], Narimah Kasim[1,2]*, Rozlin Zainal[1,2], Sharifah Meryam Shareh Musa[1,2]

[1]Department of Construction Management, Faculty of Technology Management and Business,
University Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, MALAYSIA

[2]Centre of Excellence for Facilities Management (CeFM), Faculty of Technology Management and Business,
University Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rmtb.2022.03.01.032
Received 31 March 2022; Accepted 30 April 2022; Available online 25 June 2022

Abstract: The construction industry in Malaysia faces safety and health problem due to poor safety management and inaccurate positioning and tracking issue. RFID is currently being used in many industries, such as production, healthcare, transportation, and tracking applications, especially in supply chain management. However, Radio Frequency Identification (RFID) has not been widely used in the construction industry. Therefore, this research was conducted to identify the potential, barriers, and improvement ways of Radio Frequency Identification (RFID) implementation for human tracking in safety management at the construction site. To achieve the objectives, the research was conducted using quantitative methods for primary data collection and questionnaires as the instrument. There were 254 G7 contractor target respondents from Johor, who were selected to obtain information from this research. The data were analyzed through SPSS software to determine the mean and standard deviation, and through Microsoft Excel to generate pie charts and bar for the respondents' background to get the frequency and percentage values. The results showed that RFID has the potential to capture real-time information of workers on-site and rescue injured people faster for human tracking systems. The biggest barrier to RFID implementation was a lack of understanding of RFID technology among construction workers. The highest rank for the key improvement ways was top management's need to promote the RFID technology for a human tracking system in safety management. In conclusion, the research provided a great deal of knowledge for effective safety management with RFID implementation in human tracking at the construction site.

Keywords: Construction Site, Human Tracking, RFID, Safety Management

**Corresponding author: narimah@uthm.edu.my*

1. Introduction

Radio Frequency Identification (RFID) is an automatic method used with information technology systems and is a non-contact transmission method for object identification (Mansor *et al*., 2015). RFID technology is used in many sectors such as manufacturing, transportation, healthcare, and tracking application that grasp human life towards smart life indoors (Naskar, 2017). However, Radio Frequency Identification (RFID) has not been widely used in the construction industry. Lee (2012) pointed out that the accuracy of positioning and tracking is largely affected by signal availability, but it is very difficult to maintain sufficient signal availability in construction sites. Human tracking services can make the workplace safer and healthier. A safer workplace can bring higher productivity and morale to workers (Zhao *et al*., 2016). The health and safety of the construction industry are still an area that needs improvement although occupational health and safety management systems have made progress in the application of technology (Lingard *et al*., 2019). The economic losses caused by safety accidents accounted for a high proportion of the construction project cost, causing great losses and waste to the project.

Construction industry is one of the highest industries that contribute to a country's economy. The construction industry provides employment opportunities and promotes economic development, especially in developing countries such as China, the Philippines, Vietnam, and Malaysia. However, the safety situation of the construction industry is not optimistic. Although occupational health and safety management systems have made progress in the application of technology, work health and safety are still an area that needs improvement in the construction sector (Lingard et al., 2019). The situation in developing countries is even worse due to the weak implementation of safety management (Murie, 2007). The human tracking system has proven that it can reduce the detection time and improve the accuracy of human detection and tracking (Wagh, 2014). Human-centered activity tracking services can make the workplace safer and healthier. A safer workplace can bring higher productivity and morale to workers (Zhao *et al*., 2016). Radio Frequency Identification (RFID) can be suitable for monitoring the movement of workers who are from different departments at the construction site. RFID tags were attached to construction machinery and construction workers, which can be in real-time (Chae & Yoshida, 2010).

The construction industry faces safety and health problem in Malaysia. Although the Department of Occupational Safety and Health Malaysia (DOSH) has contributed and promoted a lot of safety programs and rules to guide the safety of site workers, there are still have many accidents occurred on construction sites. Improving the safety and productivity of workers is the major issue in the construction industry, where organizations are constantly under pressure to raise productivity in a safer work environment (Arashpour *et al.,* 2018). Lee (2012) pointed out that the accuracy of positioning and tracking is largely affected by signal availability, but it is very difficult to maintain sufficient signal availability in construction sites. Although in-depth research on general human motion tracking has been conducted in the past few decades, accurate real-time tracking of specific activities is still an open research issue (Lun & Zhao, 2015). RFID is currently being used in many industries, such as production, healthcare, transportation, and tracking applications, especially in supply chain management (Naskar *et al.*, 2017). However, RFID has not been widely used in the construction industry. Various technical, financial, or ethical barriers may also block it from being widely adopted in this heterogeneous industry. Therefore, the objectives of this study are to identify the potential, barriers, and improvement ways of Radio Frequency Identification (RFID) implementation for human tracking in safety management at construction sites.

2. Literature Review

Safety management should consider all risks and accidents that may put project employees at risk. Safety management is committed to actively reducing safety risks and avoiding construction accidents and accidents. Unsafe construction sites will cause some problems, such as casualties, lost productivity, delays in work progress, medical expenses, and a negative impact on the company's reputation. Human tracking is important as it could ensure the health and safety of workers required for construction work, such as collecting attendance data of workers. The human tracking system is an effective way to identify and track the location of an object in both indoor and outdoor environments (Li *et al.*, 2016). Issue of human tracking is difficult to maintain sufficient signal availability on construction sites due to accuracy of positioning and tracking problems.

The technology implementation for human tracking includes RFID, Global Positioning System (GPS), Ultra-wideband (UWB), automated drones, and Beagle Board-xM. RFID is an automatic identification technology that uses radio frequency to capture and transmit field data. Wearable RFID tags can take the shape of a device worn on the body. For instance, bracelets and watches or a device made of electronic textiles woven into cloth (Javadpour & Memarzadeh-Tehran, 2015). GPS helps contractors contracting project resources to navigate a complex human and machine distribution network. According to Navon & Goldschmidt (2003), pointed out how to automatically collect personnel locations and convert them into man-hours spent on specific projects. Ultra-wide band (UWB) is a network between the tag and the receiver, and the communication bandwidth between them is greater than 500 MHz. As an early attempt to use UWB technology to improve the safety environment of construction sites, the technology was used in conjunction with Bluetooth devices (Giretti *et al*., 2012). The company uses UWB's powerful accuracy to create precise locations for employees and personnel to support many applications location-aware applications. High-quality cameras are installed on autonomous drones to capture real-time video and high-quality images. It can be equipped with infrared cameras, radars, and other technologies to enhance its surveillance capabilities in the field. This information can be used not only to track the construction progress but also workers, equipment, and material on a job site (Laborers' Health & Safety Fund of North America, 2018). The operation of the BeagleBoard-xM processor is to compress and determine the quality of the image to determine any human movement in the camera's field of view and display it on the monitor. Then automatically detect the background subtraction circle of the two images, and save the generated image (Gantala *et al*., 2017).

2.1 Potential of RFID for Human Tracking System

The potential of RFID implementation in human tracking for safety management includes capturing real-time information of workers on site, geofence and decreasing restricted area movements, rescuing injured people and emergency buttons faster, and worker attendance records tracking (refer to Table 1). RFID can capture real-time information of workers on site. Active RFID location tracking system enables companies to track the real-time movement of assets and personnel throughout the surveillance area. The positioning accuracy of the real-time location systems (RTLS) system is within a few centimeters. By using real-time location systems (RTLS) in the construction industry, the site manager can see everything that happens in the construction project. RTLS continuously collects and records data from RFID readers placed around construction sites. All data from the work RFID tags and device tags are collected and sent to the computer (Lee *et al*., 2012). Secondly, the potential RFID implementations for human tracking are geofencing and decreasing restricted area movements. The geofencing feature allows the site manager to set up any number of virtual areas and automatically trigger a response when the tracked tag enters or leaves an area. Geofencing mainly uses global positioning system (GPS) satellite networks and/or local radio frequency identifier RFID to create geofences (Garzon & Deva, 2015). These invisible boundaries monitor any employees entering or

leaving any set-up area of the facility. Controlled movement in and out of the area can improve safety and cut costs (Ulku, 2017).

Thirdly, RFID implementation for human tracking has the potential to rescue injured people and emergency buttons faster. When an emergency occurs, such as an explosion, fire, or gas leak, the exact location of the affected on-site workers is known, and data is sent to the reader along with the position signal (Litum, 2017). The emergency button and get-off function greatly shorten the time required to allocate the injured and reduce the risk of delayed arrival of medical assistance (Ulku, 2017). Next, RFID implementation for human tracking has the potential to worker attendance records tracking. RFID technology can maintain the attendance rate in real-time, which can be monitored on the database server. The efficiency and accuracy of the RFID-based employee attendance system are better than the manual system like the punch card system. RFID technology can maintain the attendance rate in real-time, which can be monitored on the database server (PC) (Sahoo, 2012). Workers need to carry RFID tags for work every day (Razak & Wan, 2017). RFID systems can be combined with biometric information, such as fingerprints, face recognition, or iris scanning. Figure 1 shows an example of RFID technology attached to the helmet.

Table 1: Potential Implementation of RFID

No.	Potential of RFID Implementation	Author
1	Capture real-time information of workers on site	Lee *et al.* (2012) Skibniewski (2014) Lu *et al.* (2010) Zhang *et al.* (2015)
2	Geofence and decrease restricted area movements	Garzon & Deva (2015) Ulku (2017)
3	Rescue injured people and emergency buttons faster	Ulku, (2017) Sewio (2021) Litum (2017)
4	Worker attendance records tracking	Sahoo (2012) Razak & Wen (2017) Lu *et al.* (2010)

Figure 1: Helmet with GuardRFID AT-4 active tag (RFID Journal, 2014)

2.2 Barriers of RFID Implementation for Human Tracking in Safety Management at Construction Site

The biggest barrier is the contractors cannot invest in this technology because the cost is higher. There are many other types of expenditure before the implementation of the RFID tracking system. Due to the high cost and unreliable hardware hindering the implementation of RFID, many organizations are reluctant to invest heavily in technology. Secondly, RFID will create security and privacy issues that will affect the construction industry. RFID will create security and privacy issues that will affect

the construction industry. RFID equipment can be used to locate and monitor people without their permission. Unprotected tags may be vulnerable to spoofing, traffic analysis, denial of service, or eavesdropping. This problem will lead RFID to become the biggest threat to the contractor's implementation of this system (Khalifa *et al*., 2012). Thirdly, collision problems of the tag and reader also are one of the barriers of RFID implementation for human tracking (Khadka & Hwang, 2017). Tag conflicts usually occur due to the lack of proper coordination between the reader and the tag. Attempting to read multiple tags at once may cause signal conflicts and eventually data loss (Kaur *et al*., 2011).

Next, a low level of standardization is the barrier of RFID implementation in human tracking for safety management. The different frequencies are used in different parts of the world (Doan, 2017). The two main standardization organizations for RFID are the International Organization for Standardization (ISO) and the Electronic Product Code (EPC). However, there is no agreement between ISO and EPC on which standard should be used (Ngai & Gunasekaran, 2009). Insufficient technology and knowledge are some of the barriers that hinder the RFID implementation in human tracking for safety management. The tag reading problem is another technical barrier often mentioned. Radio wave absorbing materials (such as metal or water) around or under the tag may cause poor reading results. RFID technology is still known as a complex technology and requires the necessary knowledge and experience to implement it. Many small organizations encountered difficulties in their initial technology pilot projects due to a lack of expertise in the field (Doan, 2017). Table 2 shows the summary of the barriers to RFID implementation.

Table 2: Barriers of RFID Implementation

No.	Improvement Ways of RFID Implementation	Author
1	Expensive cost	Saha *et al.* (2017) Li *et al.* (2010) Attaran (2011) Owunwanne & Goel (2010) Kaur *et al.* (2011) Pateriya & Sharma, (2011) Khalifa *et al.* (2012)
2	Security and privacy issues	Kumari (2021) Darcy *et al.* (2011) Beqqal & Azizi (2017) Kaur *et al.* (2011)
3	Collision problems of the tag and reader	Khadka & Hwang (2017) Kumari (2021) Kaur *et al.* (2011)
4	Low level of standardization	Ngai *et al.* (2009) Doan (2017) Kaur *et al.* (2011)
5	Insufficient technology and knowledge	Hinkka (2012) Attaran (2011) Doan (2017)

2.3 Improvement Ways of RFID Implementation for Human Tracking in Safety Management at Construction Site

RFID with software integration is one of the improvement ways of RFID implementation for human tracking in safety management. Integration of RFID with Building Information Model (BIM) RFID has real-time information with visibility and traceability (Li *et al*., 2018). The RFID and BIM integrated system can record the time spent in each area. This function is very important because it enables the project manager with the data needed for activity analysis. Thus, the integration of RFID and BIM technology creates a more systematic, automated, and intelligent job site (Costin *et al*., 2015). Secondly,

integration of RFID and positioning technology is one of the improvement ways for human tracking in safety management. A smart hybrid RFID-GPS human tracking system was applied using these tags to produce a certified model that aims to help save lives (Rohei, 2019). It can capture the dynamics of the 4D construction site. The site managers and contractors can evaluate labor productivity and monitoring of potential safety hazards, thereby preventing time-space conflicts and security alerts (Andoh *et al*., 2012). Thirdly, to overcome the price barrier of RFID technology, sufficient funds as one of the improvement ways of RFID implementation for human tracking in safety management. The continuous improvement of the human tracking with the RFID system also requires the investment of necessary funds to upgrade, train and build capacity. Government should provide financial or special funds to encourage and use the Internet of Things in RFID to promote future development and achievements (Badarudin *et al*., 2018).

In addition, the improvement ways of RFID implementation for human tracking in safety management is the support of senior management. The decision of management to support and invest the necessary resources is important to the improvement of RFID technology implementation (Fish & Forrrest, 2006). The support of senior management enables any low-level employee or user to trust that RFID technology can help the organization (Kereri & Adamtey, 2019). Next, the improvement way of RFID implementation for human tracking in safety management is sufficient technical support. The presence of technical workers can also provide constructive suggestions on the adjustments that need to be made (Ngai *et al*., 2010). Technical support workers can give objective opinions and suggestions on the test results. Insufficient technical support can lead to errors in system design and lead to unrealistic expectations of performance results (Ting *et al*., 2013). Table 3 presents the summary of the improvement ways of RFID implementation.

Table 3: Improvement Ways of RFID Implementation

No.	Improvement Ways of RFID Implementation	Author
1	Integration of RFID and software	Costin *et al*. (2015) Zhang *et al.* (2015) Li *et al.* (2018)
2	Integration of RFID and positioning technology	Andoh *et al*. (2012) Rohei (2019) Hutabarat *et al.* (2016) Deepika & Usha (2016)
3	Sufficient funds	Kereri & Adamtey (2019) Badarudin et al. (2018)
4	Support of senior management	Fish & Forrrest (2006) Kereri & Adamtey (2019)
5	Sufficient technical support	Ngai *et al.* (2010) Ting *et al.* (2013)

3. Research Methodology

The research methodology section describes all the necessary information that is required to obtain the results of the study. The research methodology consists of detailed information regarding workflow, strategy, and approach.

3.1 Research Design

Quantitative methods will be used in this research. The purpose of quantitative methods is to classify features, count features, and build statistical models to explain what is observed (Creswell & Creswell, 2017). G7 construction contractors in Johor serves as the target population for the research due to the highest number of fatal accident case in Johor as the target location (DOSH, 2020). Sampling is an important tool for research because the population of interest usually consists of too many

individuals, so any research project cannot be included. The target respondents to the questionnaire are 729 G7 contractors in Johor. Therefore, the number of 254 is taken as the sample size from the Krejcie & Morgan (1970) sample size table. Questionnaires as the research instruments and there are three main sections are consist of the questionnaire. The first section of this questionnaire is the respondent's background, the second section is about the potential of Radio Frequency Identification (RFID), the third part is the barriers of Radio Frequency Identification (RFID) implementation and the last part is the improved ways of Radio Frequency Identification (RFID) implementation for human tracking in safety management at the construction site.

The research includes five phases, describing the entire procedure and activities from beginning to end of this research. Phase 1 is to research and discuss the title in the problem statement. Phase 2 is about literature review, and the research title is Radio Frequency Identification (RFID) implementation for human tracking in safety management at construction sites. Phase 3 is for the data collection. It can be divided into two categories, namely primary data and secondary data. Phase 4 is conveying data analysis and results, which explains the data analysis techniques and results collected from the previous questionnaire. Phase 5 is the conclusion and recommendations of this research. At this stage, all data analysis results will be summarized. Figure 2 shows the research methodology flow chart.

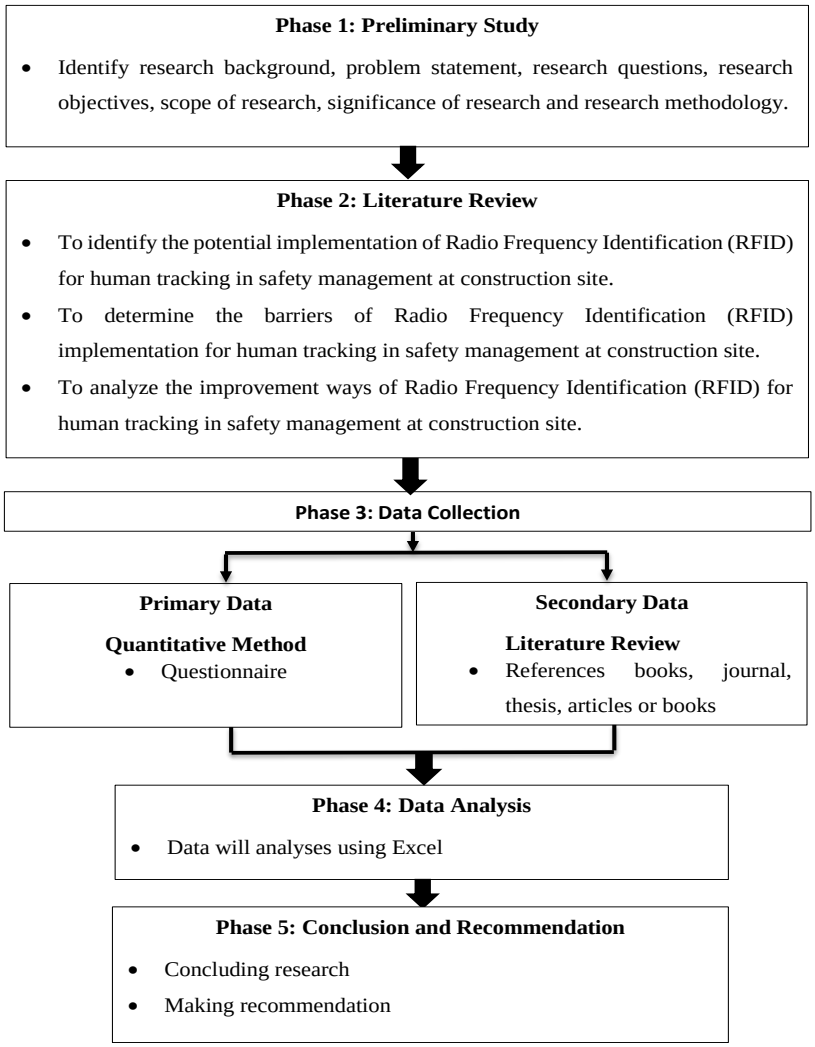

Figure 2: Research methodology flow chart

3.2 Data Collection

Primary data and secondary data are used in this research. The literature review in any research is based on secondary data. The secondary data collection sources are government publications, books, Internet articles, and journal articles (Ajayi, 2017). Primary data is the data collected from first-hand experience. The primary data of this research are collected by providing questionnaires to target respondents, using quantitative methods. The questionnaire focused on the objectives of this research to ensure that the objectives are achieved.

3.3 Data Analysis

The data collected from the questionnaire delivery process was analyzed by SPSS and Excel software to conduct descriptive analysis. After the data is analyzed, the ranking can be determined by comparing the averages. The percentage will be understood by looking at the frequency table generated by SPSS. For data analysis, it used Microsoft Excel to generate pie charts to obtain frequency and mean scores. These values will appear in graphs and tables to display the information more clearly.

4. Results and Discussion

This research helped to identify the potential, barriers, and improvement ways of implementing Radio Frequency Identification (RFID) for human tracking in safety management at the construction site. G7 contractors will be able to implement the Radio Frequency Identification (RFID) for human tracking in safety management at the construction site.

4.1 Validity and reliability in the pilot test

The pilot test improved the validity, reliability, accuracy, and efficiency of the entire study (Ruel *et al.*, 2016). It is a trial run of the entire study from beginning to end to increase the likelihood of the main study being successful. Four respondents participated in the pilot study which was the lecturers at the University Tun Hussein Onn Malaysia (UTHM). The Cronbach Alpha coefficient was the most widely used indicator of internal consistency. The Likert scale was recognized as the most accepted measure of reliability when used (Taherdoost, 2016). The research used Cronbach's Alpha to evaluate the reliability of variables and 146 sets of questionnaires were used to evaluate the reliability analysis. Table 4 specified the result of reliability statistics for the research. Cronbach's Alpha's actual tested reliability test was 0.861 with 30 questions and it represented very good (refer to Table 4). Table 5 showed the response rate of the questionnaire was 100% distributed, 57.5% received, and 42.5% not received.

Table 4: Reliability Statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
0.861	30

Table 5: Response Rate

Questionnaire	N	Respondent Rate (%)
Questionnaire Distributed	254	100
Questionnaire Received	146	57.5
Questionnaire Not Received	108	42.5

4.2 Descriptive analysis

(a) Respondent Background

All the data of the respondents' background, including the highest academic qualification, working position, work experience, and experience in RFID usage were shown in Table 6. The frequency and percentage of respondents who participated were included in the data. According to Table 6, most of the highest academic qualifications were bachelor's degrees (49.3%), because the field of study was mainly a bachelor's degree. In addition, the most working position was a contractor (23.3%), because most respondents were contractors. Most respondents have work experience between 1 and 5 years (35.6%) because most respondents do not have more than 5 years of work experience in the field. The majority of working experience of RFID usage was less than 3 years (54.1%) which also means that RFID was not widely used in the construction industry. Moreover, some respondents mentioned that they usually used QR codes to scan the workers' attendance at the construction site. The workers needed to install an app on their phones to scan QR codes placed at building entrances. The existence of other technology choices will also become an obstacle for contractors to implement RFID technology at the site.

Table 6: Respondent Background

Item		Frequency	Percentage (%)
Highest Academic Qualification	Diploma	33	22.6
	Bachelor Degree	72	49.3
	Master	20	13.7
	PhD	18	12.3
	Other (SPM)	3	2.1
Working Position	Project Manager	29	19.9
	Contractor	34	23.3
	Site Supervisor	28	19.2
	Project Engineer	26	17.8
	Engineer	25	17.1
	Other (Quantity Surveyor)	4	2.7
Working Experience	1-5 years	52	35.6
	6-10 years	47	32.2
	11-15 years	35	24.0
	16 years and above	12	8.2
Experience in RFID usage	Less than 3 years	79	54.1
	3-5 years	48	32.9
	5-9 years	15	10.3
	10 years and above	4	2.7

(b) Potential implementation of RFID for human tracking system in safety management

Table 7 illustrated the potential implementation of RFID for human tracking systems in safety management. There were two highest means of the potential implementation of RFID which were "Capture real-time information of workers on-site" (4.404) and "Rescue injured people faster" (4.404) within 146 respondents. Active RFID location tracking system enables companies to track the real-time movement of assets and personnel throughout the surveillance area. Lu et al. (2010) surveyed the real-time location information of the whereabouts of on-site personnel was very helpful for safety management. According to Ulku (2017), the emergency button with RFID technology greatly speeds up rescue operations.

The lowest means of the potential implementation of RFID was 3.622 in ranking 12 which was "Improve overall efficiency of workers" and the second-highest standard deviation (0.933). Therefore, the average mean in this section was 4.03.

Table 7: Potential Implementation of RFID

No.	Item	N	Mean	Standard Deviation	Ranking
1	Capture real-time information of workers on site	146	4.404	0.757	1
2	Rescue injured people faster	146	4.404	0.649	1
3	Send alerts in an emergency	146	4.315	0.672	3
4	Provide real-time information on construction workers	146	4.288	0.684	4
5	Provide more accurate human tracking	146	4.240	0.736	5
6	Real-time attendance tracking	146	4.027	0.838	6
7	Provide warning signals when workers enter the dangerous zone	146	3.966	0.746	7
8	Monitor workers' movement in construction site	146	3.904	0.708	8
9	Provide geographic boundaries	146	3.829	0.949	9
10	Provide better safety construction site	146	3.706	0.933	10
11	Reduce accident costs	146	3.651	0.876	11
12	Improve overall efficiency of workers	146	3.622	0.933	12
	Average Mean		4.003		

(c) Barriers of RFID implementation for human tracking system in safety management

Based on Table 8 below, the highest mean of barriers for RFID implementation was "Lack of understanding for RFID technology" with 4.397. RFID technology was still known as a complex technology and requires the necessary knowledge and experience to implement it. According to Doan (2017), due to a lack of expertise in this field, many organizations encountered difficulties in their initial technical projects.

Meanwhile, the lowest mean was "Lack of standardization in different parts of the world" which was 3.856, and the highest standard deviation (0.910) as shown in Table 8. However, most respondents believed that standardization of RFID technology was not the main issue that hinders the implementation of RFID for human tracking systems in safety management. Thus, the average mean was higher which was 4.199.

Table 8: Barriers of RFID

No.	Item	N	Mean	Standard Deviation	Ranking
1	Lack of understanding for RFID technology	146	4.397	0.783	1
2	High cost of development, implementation, and maintenance of equipment	146	4.370	0.779	2
3	High cost of technical input	146	4.260	0.752	3
4	High equipment expenses (tags and readers) lead to higher engineering costs	146	4.253	0.741	4
5	High risk of RFID tags being easily copied by criminals	146	4.199	0.802	5
6	RFID devices can be used to monitor personnel without permission.	146	4.192	0.736	6
7	Insufficient skilled workers in RFID implementation	146	4.151	0.755	7
8	Collision problems of the tag and reader can lead to data loss	146	4.110	0.806	8
9	Lack of standardization in different parts of the world	146	3.856	0.910	9
	Average Mean		4.199		

(d) Improvement Ways of RFID implementation for human tracking system in safety management

According to Table 9, the highest mean of improvement ways for RFID implementation was "Top management leads the widespread of RFID technology in safety management" with 4.459 and the lowest standard deviation (0.655). The decision of top management to support and provide necessary resources was critical to the success of RFID technology implementation. Kereri & Adamtey (2019) investigated that top management can become the bellwether in investing and developing clear strategies for the implementation of RFID in the safety management of construction sites.

However, the lowest mean was "Government provides financial or special funds" which was 3.452 and the standard deviation was 0.976 as shown obviously below Table 9. Most respondents did not think this was a major improvement way and respondents stated that government just give incentives for G1 to G7 contractors in the Budget2021. Thus, the total average mean was higher which was 4.002.

Table 9: Improvement Ways of RFID

No.	Item	N	Mean	Standard Deviation	Ranking
1	Top management leads the widespread of RFID technology in safety management	146	4.459	0.655	1
2	Staff development in RFID technical skills training	146	4.404	0.748	2
3	Top management provides financial support in RFID	146	4.384	0.754	3
4	Improve the visibility of real-time information in construction site	146	3.980	0.867	4
5	Improve the traceability of real-time information in construction site	146	3.959	0.821	5

6	Improve the security of RFID through integration RFID with software	146	3.884	0.835	6
7	Smart hybrid RFID-GPS human tracking system capture the dynamics of 4D construction site	146	3.870	0.857	7
8	Government applies for tax-free implementation of RFID	146	3.623	0.998	8
9	Government provides financial or special funds	146	3.452	0.976	9
	Average Mean		4.002		

5. Conclusion

In summary, this research study used SPSS and Excel to analyze the successfully collected questionnaire data, and all the objectives of this research study have been successfully achieved. The results showed that the potential implementation of RFID can capture the real-time information of workers on-site and rescue the wounded faster. Lack of understanding for RFID technology as the main barriers faced by the contractor and the top management leads to the widespread of RFID technology as critical improvement ways of RFID implementation can also increase the number of users of RFID's human tracking system in safety management. However, this study also had certain limitations such as the choice of target respondents being limited and taking a long time to collect data. Hence, there were few recommendations for advancing the results of the research study. In the future, for any researcher who intended to conduct research in this research field, it is recommended to combine two research methods, namely quantitative and qualitative methods. The recommendation for the construction industry was the integration of the "internet of things" (IoT) and RFID-based labor tracking system as a real-time safety early warning system to prevent accidents and improve safety management at the construction site. For the recommendation for future research, the integration of these two methods, the researcher will be able to have a comprehensive and thorough understanding of the potential of RFID. This will provide a clear insight into the report of the finding.

Acknowledgment

The author would like to thank the Faculty of Technology Management and Business and Universiti Tun Hussein Onn Malaysia for their support.

References

Ajayi, O. V. (2017). Primary Sources of Data and Secondary Sources of Data. Benue State University, Makurdi: Ph.D. Report. Retrieved on May 19, 2021, from: https://www.researchgate.net/publication/320010397_Primary_Sources_of_Data_andSecondary_Sources_of_Data

Andoh, A. R., Su, X., & Cai, H. (2012). A Framework of RFID and GPS for Tracking Construction Site Dynamics. Construction Research Congress 2012. 0(0), pp. 818-827.

Arashpour, M., Kamat, V., Bai, Y., Wakefield, R., & Abbasi, B. (2018). Optimization modeling of multi-skilled resources in prefabrication: theorizing cost analysis of process integration in off-site construction. Automation in Construction. 95(0), pp. 1–9.

Badarudin, U., Din, W., Prasetyo, Y., Musa, Z., & Kasim, S. (2018). Internet of Things: An Implementation and Its Challenges in Malaysia.International Journal on Advanced Science, Engineering and Information Technology. 8(6), pp. 2641-2647.

Chae, S., & Yoshida, T. (2010). Application of RFID technology to prevention of collision accident with heavy equipment. Automation in Construction, 19(3), pp. 368–374.

Costin, A., & Teizer, J., & Schoner, B. (2015). RFID and BIM-enabled worker Location Tracking to Support Real-time Building Protocol Control and Data costinVisualization. Journal of Information Technology in Construction, 20(0), pp. 495-517.

Creswell J. D., & Creswell J. W. (2017). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. 5th Ed. Singapore: SAGE Publications. 2017.

Doan, B. (2017). Radio frequency identification (RFID) and its impacts on logistics activities.: Degree Thesis.

Fish, L. A. & Forrest W. M. (2006). The 7 success factors of RFID. Supply Chain Management Review 10(6), pp. 26-32.

Gantala, A., Nehru, K., Telagam, N., Anjaneyulu, P., Swathi, D. (2017). Human Tracking System using Beagle Board -xM. International Journal of Applied Engineering Research, 12(16), pp. 5665-5669.

Garzon, S. R., & Deva, B. (2015). Infrastructure-Assisted Geofencing: Proactive LocationBased Services with Thin Mobile Clients and Smart Servers. 2015 3rd IEEE International Conference on Mobile Cloud Computing, Services, and Engineering, 0(0), pp. 61-70.

Giretti, A., Carbonari, A., & Vaccarini, M. (2012). Ultra-Wide Band Positioning Systems for Advanced Construction Site Management. In: Fouzia E. (Ed). New Approach of Indoor and Outdoor Localization Systems. InTech. pp.89-112; 2012.

Hinkka, V. (2012). Challenges for building RFID tracking systems across the whole supply chain. International Journal of RF Technologies Research and Applications, 3(3), pp. 201-218.

Javadpour, A., & Memarzadeh-Tehran, H. (2015). A wearable medical sensor for provisional healthcare. 2015 2nd International Symposium on Physics and Technology of Sensors (ISPTS), 0(0), pp. 293-296.

Kaur, M., Sandhu, M., Mohan, N. & Sandhu, P. (2011). RFID Technology Principles, Advantages, Limitations & Its Applications. International Journal of Computer and Electrical Engineering, 3(1), pp. 151-157.

Kereri, J.O. & Adamtey, S. (2019), "RFID use in residential/commercial construction industry", Journal of Engineering, Design and Technology, 17(3), pp. 591-612.

Khalifa, O. O., Chebil, J., Abdalla, A.-H., & Hameed, S. (2012). Ethical Issues in Monitoring and Based Tracking Systems. IIUM Engineering Journal, 12(5), pp. 123-129.

Khadka, G., & Hwang, S. S. (2017). Tag-to-Tag Interference Suppression Technique Based on Time Division for RFID. Sensors (Basel, Switzerland), 17(1), pp. 78.

Laborers' Health & Safety Fund of North America (2018). Using Drones to Monitor Construction Safety. Retrieved on May 10, 2021, from https://www.lhsfna.org/index.cfm/lifelines/august-2018/using-drones-to monitorconstruction-safety/

Lee, H.S., Lee, K.P., Park, M., Baek, Y., & Lee, S. (2012). RFID-Based Real-Time Locating System for Construction Safety Management. Journal of Computing in Civil Engineering, 26(3), pp. 366–377.

Li, S., Godon, D. & Visich, J. (2010). An exploratory study of RFID implementation in the supply chain. Management Research Review,33(10), pp.1005–1015.

Li, B., Du, Z., Xie, D., & Huang, L. (2018). Research on Engineering Construction Safety Integration based on BIM and RFID. MATEC Web of Conferences, 246. Retrieved on May 10, 2021, from doi:10.1051/matecconf/201824603035

Li, H., Chan, G., Wong, J. K. W. and Skitmore, M. (2016). "Real-Time Locating Systems Applications in Construction". Automation in Construction, 63(0), pp.37-47.

Lingard, H., Pirzadeh, P., Oswald, D., (2019). Talking safety: health and safety communication and safety climate in subcontracted construction workgroups. Journal Construction Engineering Management. 145(5), pp. 1-11.

Litum (2017). How RFID RTLS Locates Employees with Sub-meter Location Accuracy? Retrieved on May 20, 2021, from https://litum.com/blog/rtls-rfid-employeelocation-tracking/

Lu, W., George Q., Huang B., & Li., H. (2010). Scenarios for applying RFID technology in construction project management. Automation in Construction,8(7), pp.101-103.

Lun, R. & Zhao, W. (2015). A survey of applications and human motion recognition with Microsoft Kinect. International Journal Pattern Recognition and Artificial Intelligent. 29(5), pp. 1-48.

Mansor, M. N., Ustadi, M. N., & Shariffuddin, M. A. (2015). The Potential of Radio Frequency Identification (RFID) Technology Implementation in Malaysian Shipbuilding Industry. Journal of Transport System Engineering, 2(1), pp. 31-36.

Murie, F., (2007). Building safety—an international perspective. International Journal of Occupational and Environmental Health, 13(0), pp. 5-11.

Naskar, S., Basu, P., Sen, A. K. (2017). A Literature Review of the Emerging Field of IoT Using RFID and Its Applications in Supply Chain Management. In Lee. USA: IGI Global. In the Internet of Things in the Modern Business Environment. pp. 1-27; 2017.

Navon, R., & Goldschmidt, E. (2003). Monitoring labor inputs: Automated- Data-Collection Model and Enabling Technologies. Automation in Construction,12(2), pp. 185-199.

Ngai, W. T., & Gunasekaran, A. (2009). RFID adoption: Issues and challenges. International Journal of Enterprise Information Systems, 5(1), pp. 1-8.

Pateriya, R. K. & Sharma, S. (2011). The Evolution of RFID Security and Privacy: A Research Survey. 2011 International Conference on Communication Systems and Network Technologies, 0(0) pp. 115-119.

Razak, M., & Wen, C.C. (2017). Staff attendance system using RFID. International Journal On Informatics Visualization,1(4) pp.1-6.

RFID Journal. (2010). How much does an RFID tag costs today? Retrieved on May 20, 2021, from: https://www.rfidjournal.com/question/what-is-the-price-ofrfid-tags

Rohei, M.S. (2019). Design and implementation of a hybrid RFID-GPS human tracking system. Universiti Malaya: Master's Thesis

Ruel, E., Wagner III, W. E., & Gillespie, B. J. (2016). The Practice of Survey Research: Theory and Applications. United State of America: SAGE Publications. 2016.

Saha, H. N., Mandal, A., & Sinha, A. (2017). Recent trends in the Internet of Things. 2017 IEEE 7th Annual Computing and Communication Workshop and Conference (CCWC), 0(0). Retrieved May 11, 2021, from doi:10.1109/ccwc.2017.7868439

Sahoo, P. (2012). A RFID Based Attendance Tracking System. IOSR Journal of Environmental Science, Toxicology and Food Technology, 2(2), pp. 12-17.

Sewio (2021). Increase Safety and Security with Sewio's Employee Location Tracking System. Retrieved on May 28, 2021, from https://www.sewio.net/peopleemployee-indoor-location-tracking-and-monitoring/

Taherdoost, H. (2016). Validity and Reliability of the Research Instrument; How to Test the Validation of a Questionnaire/Survey in a Research. SSRN Electronic Journal, 5(3), pp. 28-36.

Ting, S. L., Tsang, A. H. C., & Tse, Y. K. (2013). A Framework for the Implementation of RFID Systems. International Journal of Engineering Business Management, 5(9), pp. 1-13.

Ulku, A. (2017). The Next Generation In Personnel People Tracking: Active RFID Technology Has Allowed for Enhanced Security and Safety. IEEE Consumer Electronics Magazine, 6(4), pp. 122–124.

Wagh, K. V. (2014). Human Tracking System. Proceedings of the 2014 International Conference on Electronic and Communication System (ICECS), 8(2), pp.1-6.

Zhang, S., Teizer, J., Pradhananga, N. and Eastman, C.M. (2015), "Workforce location tracking to model, visualize and analyze workspace requirements in building information models for construction safety planning", Automation in Construction, 60(0), pp. 74-86.

Zhao, W., Lun, R., Gordon, C., Fofana, Abou-Bakar. M., Espy, D.D., Reinthal, M. A., Ekelman, B., Goodman, G. D., Niederriter, J. E. & Luo, X. (2016). A Human Centered Activity Tracking System: Toward a Healthier Workplace. Research in IEEE Transactions on Human-Machine Systems, 47(3), pp. 343-353.