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The Use of Drone Technology for Project Monitoring in Construction Sites

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Abstract: Drones are not excluded from appearing in the construction sector in this current age of technology growth. Numerous areas such as mine mapping and transportation surveillance, are exhibiting increased interest in using drones. Malaysia's construction industry continues to face numerous challenges, including low quality, low productivity, inexperienced labor, project delays, poor maintenance, non-conducive working conditions, and high accident rates. Even though the issues faced by the construction industry during the construction stage are constantly being researched, there are still insufficient studies that provide an overview of the topic regarding the use of drones in the Malaysia construction sector. This study objectives are to study the factors that hinder the use of drone technology for project monitoring in construction sites and to identify steps that can be taken to overcome the factor that hinder the use of drone for project monitoring in construction sites. This study involved quantitative method which is questionnaires to G7 construction companies in Melaka and only 64 sets of the surveys with 52.03% response rate returned. All data was analysed using SPSS descriptive statistics. The findings show that the main factor that hinder the use of drone technology for project monitoring in construction sites is drone operation control and main step that can be taken is battery replacement. This study will contribute to improving industry participants' understanding of drone use in construction, which will lead to an increase in drone users in the industry.

Keywords: Drone Technology, Factors, Steps, Construction Industry

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1. Introduction

The construction industry is a very important industry in driving development in Malaysia and subsequently generating economic development in the country. The construction industry entsails a number of process, beginning with the design, description phase and continuing through the construction phase and post-completion phase (RIBA, 2007). In addition, the booming construction industry is an important contributor to the country's economic growth, while the industrial downturn construction is the clearest picture of the country's economic crisis. This clearly shows that the construction industry is largely driven by economic growth country.

Kamal, E.M. & R. Flanagan, (2012) stated that the Malaysian construction industry faces many challenges, including low quality, low productivity, unskilled workers, project delays, poor maintenance, lack of conducive working conditions, and high rates of workplace accidents. In the current state of Malaysian business sector, coordination of efforts takes place at weekly or biweekly planning meetings (Garcia-Lopez & Fischer, 2014).

This study set out to answer question about how drones technology can be used in the construction industry, what factors may stand in the way of such use and how those factors can be overcome. Drones are widely hailed as a cutting-edge technological advancement. However, drones have the potential to aid construction in a variety of way across the board. Integrating IT on the building sector: and evaluation of Malaysian contractors` technological preparedness was conducted (Jaafar *et al*, 2007).

Applying drone technology can bring faster cycle and response time and sharing of up-to-date information between project teams in contractor organization, which in turn can lead to reducing errors, cutting down on delays, and ending the pervasive rework cycle (Jaafar *et al*,. 2007).

2. Literature Review

The application of Unmanned Aerial Vehicles (UAVs) continues to transform a variety of sectors and fields as a result of rapid technological advancement and innovation. With the introduction of intelligent Drone-Powered solutions and the deployment of scientific instruments, businesses have given traditional surveys and safety inspections of assets a new designation. Monitoring and planning in construction sites are significant that employs UAVs for improved performance, speed, and accuracy of data (Equinox`s Drones, 2020). This chapter discuss in detail some of the things related to the use of drones. The discussion began by looking at what is meant by drones as well as outlining the need for drones for project monitoring in construction sites. The use of drones will be discussed further this chapter will relate to the objectives that have been made.

2.2 Definition of Project Monitoring

Harris and McCaffer, (2013) define monitoring as the act of comparing actual progress and actual resource utilization to what was planned, as well as the act of making decisions to alter future outcomes and bring the project back in line with its original schedule control.

(a) Project Monitoring Method

On a construction site, the method for monitoring progress can be divided into two categories which are the conventional method and the automatic method. Omar and Nehdi’s, (2016) stated that the method of monitoring and evaluation in current construction projects is less organized, referring to the method of manual progress monitoring, and that the method of progress monitoring used more recently is more automatic and integrated.

(b) Importance of Project Monitoring

Project monitoring is a key management management function for a construction project's

successful completion. The success of a project depends on the accuracy of the information gathered from the work performed on the construction site, which will then be used to compare the actual work performed on the construction site with the planned work. Monitoring performed multiple times per day enables the collection of data regarding the work completed on that day, which can then be used to estimate the amount of work completed on that day El Omari and Moselhi, (2008).

(c) Manual Project Monitoring

Construction managers and site supervisors must continuously monitor progress by manually monitoring the progress of each location on the construction site in order to document such progress in order to avoid delays and excessive expenditures. Identifying variances in the schedule is possible by comparing the current situation to the anticipated progress (Yang *et al*., 2015).

(d) Manual Project Monitoring Process

Monitoring progress on construction sites is not an easy task, as it requires a great deal of information obtained from a variety of sources and presented in a variety of formats pertaining to a number of functions, including construction methods, scheduling, resource management, cost and order changes, and quality control. In addition, it is difficult to detect and document any alterations or errors that may occur during construction, Omar and Nehdi`s(2016).

(e) Challenges of Manual Progress Monitoring

Soman *et al*. (2017) stated that construction supervisors spend as much as 30 to 50 percent of their time analysing the information obtained, despite the fact that the information required for the analysis is frequently unavailable. As a result, corrective action cannot be implemented in a timely manner. Due to slowness in gathering and evaluating information, delaying the implementation of effective control measures. In order for construction projects to be completed on time and within budget, proper monitoring is required.

2.3 Disadvantages of Manual Project Monitoring

Soman *et al*, (2017), described the manual monitoring method as having resulted in information that was slow and inaccurate, in addition to incurring additional costs. It has been reported that as much as 2 percent of construction work is dependent on manually tracking and recording progress information.

2.4 The Emergence of Drones in Construction Industry

The construction industry is not lagging behind in the use of drone technology to conduct real-time monitoring and obtain high-quality photographs and videos for the purpose of documenting progress, despite the fact that the construction industry ranks second-to-last in the total use of drones. In the future, however, the development of reforms is anticipated to lead to a rise in the use of drones in the construction industry (Tatum and Liu, 2017).

(a) Monitoring Progress using Drone

Drones can be used to monitor the progress of work on building sites (Tatum and Liu .2017). (Tatum and Liu .2017). The usage of drones in the construction sector encompasses progress monitoring, site management, marketing, inspection, safety monitoring, earthworks and storage tracking of building materials. In the study as well, the use of drones in the construction industry as a progress monitoring tool earned the greatest response compared to other uses.

(b) Progress Monitoring Process using Drone

According to Liu *et al*. (2014) normally the data in the form of photographs and videos collected by drones during monitoring progress and inspections at construction sites would be converted into three -dimensional (3D) models. Two -dimensional (2D) photographs acquired during monitoring can be turned into three -dimensional (3D) models using appropriate software that will then be linked to

three -dimensional computer aided design (3D CAD) models to allow project progress to be evaluated (Son and Kim, 2010).

(c) Drones Autonomy Level

Drones are always autonomous because they lack a pilot, and there is a distinction between an automatic system and an autonomous system. An automated system is a system that is completely pre-programmed to perform tasks on its own, whereas an autonomous system can deal with unforeseen situations by using pre-programmed rules to help make decisions, whereas an automated system lacks this freedom of choice (Vergouw, 2016).

2.5 Use of Drones in Construction Sites

According to Molla D, (2015), drone technology can benefit every phase of a construction project. Here are the phases where drones can be advantageous:

a) Design Phase. The drone is ideal for tall building designs due to its ability to capture real views from a variety of heights and directions, as well as its ability to take photographs of highly detailed site plans with high resolution. Using photo mapping software, the image can then be shaped into an accurate 3D model.

b) Construction Phase. Drones can be used easily, quickly, and cheaply to capture videos and photographs of progress from the airspace, eliminating the need to hire a photographer by boarding a plane, which is time-consuming, expensive, and carbon intensive. In addition, drones can conduct inspections quickly and safely in hard-to-reach locations.

According to Lawson, (2017), applications for drones in the construction industry, uses drones in the following ways:

a) Land surveying. The use of drones has made land surveying work more efficient, and the cost of equipment and labour can be reduced compared to the past, when land surveying work was a difficult and expensive aspect of construction. In addition to providing general information, drones also provide detailed information on the landscape and surrounding area of the studied land.
b) Marketing and promotion. Drones are used to photograph the development site from a variety of angles from the airspace. The images captured by the drone will then be rendered in 3D to provide an accurate representation of the client's proposed ideas.
c) Safety and insurance. Due to the high cost of insurance for construction projects, drones can be used to identify any issues that arise on the job site so that they can be resolved before requiring greater responsibility, while also improving and maintaining safety records.
d) Job progress to client. Regular use of drones to capture images and videos of the construction site's progress enables clients who lack the time to visit the site to obtain the most up-to-date information on the site's progress. In addition, it allows the contractor to focus solely on their work, as they are no longer required to respond to clients' inquiries regarding the construction site's progress.
e) Monitoring multiple job on sites. Monitoring of work on the construction site can be done without having to move a lot as the drone can provide a clear picture of what is happening and what needs to be done to ensure that all work on the construction site runs smoothly, safely and according to plan.
f) Inspection in construction. By utilising a drone to inspect every nook and cranny of a construction site in order to determine the actual state of the site, inspections can be performed quickly, easily, and safely.
g) Monitoring workers. Drones can be used to monitor workers on construction sites who do not follow the rules in order to maintain worker safety and productivity without the need to hire additional site supervisors.

2.5.1 Types of Drones

There are numerous varieties of drones, but commercial drones are the norm in the construction industry. Some models use fixed wings, while others feature rotors. The primary distinctions between them lie in their respective designs and applications.

2.6 Factors that hinder the Use of Drone Technology for Project Monitoring in Construction Sites

(a) Number of Potential Accident Risk

According to Tatum (2017), there are a number of potential accident risks, with prospective drone crash risk, worker or public injury risk, privacy and property damage on construction sites or in the environment ranking in the top four.

(b) Drone Operation Control

Drones must be operated by categorize pilots based on Tatum and Liu (2017) remark noting that the United States Federal Aviation Administration (FAA) has announced new rules regarding the granting of Pilot Remote Control Certificates and defined the requirements to category drones for commercial usage in August 2016.

(c) Issues Associated with Commercial Drone Flight

Wilson, (2014), has outlined a number of issues associated with commercial drone flights, such as the potential for a violation of a person's privacy rights, the impact of increased drone use on air traffic, and possible violations that could put the public in danger.

(d) Small Battery Capacity

One of the greatest obstacles for drone applications in the construction industry is the short flight time resulting from the small battery capacity. While charging, the drone will be in the air for 25 minutes. Multiple battery packs permit the drone to fly for a full day, but it must be recharged every 25 minutes

2.7 Steps That Can be Taken to Overcome the Factor That Hinders the Use of Drones for Project Monitoring in Construction Sites

(a) Using Appropriate Drone Size

Using appropriate drone size. The drone's small size enables it to fly closer and enter the inside of a construction site. Prior to flying in difficult and limited regions, drone pilots must learn and polish their skills in open terrain. (Opfer and PE, 2014).

(b) Malaysia Construction Industry Development Board (CIDB) Initiative

Malaysian Construction Industry Development Board (CIDB) Initiative. Developers' trust in a contractor's ability to complete a project is bolstered by CIDB's initiative to introduce new technology to staff in order to boost productivity and help meet deadlines for each construction project, CIDB, (2017).

(c) The Government of Malaysia Encourages the Private Sector to Innovate In The Usage Of Drone Services.

The government's primary objective is to assist Malaysia in becoming a key centre for drone manufacturing and testing in Southeast Asia. MydroneX collaborated with the Malaysian Digital Economy Corporation (MDEC), which focuses on each drone-related technology to boost interest in the usage of drone technology in the construction industry in particular, to host an exhibition of drones.

(d) Battery Replacement

If further flying time is needed to continue work, a replacement battery is required. Using a power source such as a lithium-polymer (li-po) battery with a higher electric current charge density can extend the flight time of a drone. (Opfer and PE, 2014).

3. Research Methodology

Research methodology is a strategy for designing, collecting, and analyzing data to create evidence to support a study (Fellow & Liu, 2009). Methodology defines how a problem is investigated and why particular techniques and methodologies are utilized. The objective of the methodology is to assist readers comprehend the application of the approach in greater depth by describing the research process.

3.1 Research Design

The study employs many research methodologies, each of which has its own set of features, such as methodology and data analysis. According to Tarique, (2010), the researcher uses research methodologies and findings to acquire data, whereas the research design is determined by the study objectives. Depending on the study design, many methodologies are used in data gathering processes.

3.2 Research Method

In this study, questionnaire-based quantitative research used. In order to obtain objective, quantitative methodologies are employed in research. This strategy includes 123 construction companies in the Melaka as respondents. The given questionnaire contains a variety of question forms. The primary objective of this questionnaire is to elicit responses to the questions that occur during the formulation of study objectives. Next, during data analysis, the software Static Package Social Science (SPSS) employed as a mathematical tool.

3.2.1 Quantitative Method

Frequently, quantitative procedures include the distribution of closed questions to responders via hand, mail, or email. To collect quantitative data for this study project, a series of pertinent questions was carefully crafted and delivered to construction professionals in the Malaysian building industry.

3.2.2 Questionnaire

Using a literature review process, the questionnaire was designed. This study's questionnaire consists of four (4) section. Utilizing a questionnaire to collect data on a desired variable is an effective approach of data collecting. Already-completed questionnaires are circulated via email and social media channels like WhatsApp and Telegram. A formal email addressed to the construction company, and then distributed to their employees via social media platforms such as WhatsApp, Telegram, and email, Google forms and face to face approach.

3.2.3 Likert-Scale Question

Likert scales are used to display the survey results. An attitude can be scaled or quantified based on a set of statements and answer types. The number of possible answers on a Likert scale ranges from one to five. The responses range from "Strongly Agree" to "Strongly Disagree," giving the creator of the survey a complete picture of what respondents are thinking and how much they agree with each other.

3.3 Population

A population can be a state or a collection of people who share specific qualities. This is the group of people from which a statistical sample is taken for research in statistics. As a result, any collection of persons that share a feature can be referred to as a population. This research carried out by G7 active

contractors registered with the Construction Industry Development Board (CIDB) in Melaka. The population size of G7 active contractors registered with CIDB is 176 (CIMS, 2022).

3.3.1 Sample Size

The sample size value can be determined by Table 3.1, which is population (N) and sample (S) with the methods of Krejcie and Morgan. Based on Table 3.1, the population size is 176. The sample size needed in this research is 123 respondents from the G7 contractor company in Melaka.

3.4 Data Analysis

The data collection is analysed by the Statistical Package for Social Sciences (SPSS), which produce an accurate final result. As part of this study, a Likert Scale Questionnaire are used to obtain data. There is a table, a graph, and a pie chart used to compile the data.

3.4.1 Frequency Analysis

In the form of a percentage or a number, the objective of frequency analysis is to determine the frequency of responses given by respondents in response to the questions posed (Chua, 2006). The frequency of the number of responses chosen by respondents shows their preferences. Using this strategy, respondent information from Part A is gathered for analysis.

3.4.2 Descriptive Analysis

In research, descriptive analysis the features of data. From sample and measurement data, clear reports are created. They serve as the foundation for quantitative data analysis with fundamental graphical analysis (Zikmund *et al*., 2003). Descriptive statistics are utilised to portray quantitative data in an intelligible fashion. In a research endeavour, various measures may be employed. Alternately, researchers may undertake a massive survey of a huge number of individuals. Descriptive analysis can distil enormous data sets. Descriptive statistics aid in the reduction of vast amounts of data. Three steps comprise descriptive analysis: gathering, cleaning, and applying methods (Zikmund *et al*., 2003). Participants were required to complete questionnaires that included central tendency measures. The three averages that make up a control measure for central tendency are the mean, median, and mode. In contrast, researchers in this study only employed meaning for descriptive analysis.

4. Results and Discussion

(a) Section A: Respondent`s Background Summary

As stated in Table 1, 64 out of 123 G7 companies who registered with CIDB submitted data. All respondents work for a Melaka-based construction company. The respondent's background comprises their gender, age, and race. It can confirm that the data acquired by the researcher from the respondent is authentic and that the respondent's response is useful for this research.

Table 1: Section A respondent`s background summary

No	Respondent Background	Frequency	Percentage (%)
1	Gender		
	Male	43	67.2
	Female	20	32.8
2	Age		
	18-29	42	67.2
	30-29	17	26.6
	40-49	3	4.7

	50-59 60 and above	0	1.6
3	Race Malay Chinese Indian	56 5 2	89.1 7.8 3.1

(b) Section B: The Factors That Hinder the Use of Drone Technology for Project Monitoring Progress and Safety in Construction Sites (Objective 1)

From the Table 2, drone operation control is the most factor aspect that the respondents responded. It follows with small battery capacity and number of potential risk. On the other hand, the least factor is issues associated with commercial drone flight. Drones must be operated by categorize pilots based on Tatum and Liu (2017) remark noting that the United States Federal Aviation Administration (FAA) has announced new rules regarding the granting of Pilot Remote Control Certificates and defined the requirements to category drones for commercial usage in August 2016. Unnecessary procedures must be ruthlessly eliminated in order to use drones in the field (Yoo, 2021).

Table 2: Section B data analysis summary

No	Problems	Mean	Consent Level	Ranking
1	Number of Potential Risk	3.56	Agree	3
2	Drone Operation Control	4.055	Strongly Agree	1
3	Issues Associated with Commercial Drone Flight	4.5485	Strongly Agree	4
4	Small Battery Capacity	3.68	Strongly Agree	2

(c) Section C: The steps that can be taken to overcome the factor that hinders the use of drones for project monitoring in construction sites (Objective 2)

Table 3 shows four steps that can be taken to overcome the factor that hinder the use of drone in construction sites. The main step using the battery replacement. Monitoring battery health and equilibrium to lessen the risk of failure. If further flying time is needed to continue work, a replacement battery is required. Using a power source such as a lithium-polymer (li-po) battery with a higher electric current charge density can extend the flight time of a drone. (Opfer and PE, 2014). The hovering, wireless connections, data transfer, and picture processing of drones are often powered by batteries. Due to power constraints, a decision must be made on whether data and image processing should be performed onboard in real-time or offline (Shahmoradi, Talebi, Roghanchi, & Hassanalian, 2020).

Table 3: Section C data analysis summary

No	Steps	Mean	Consent Level	Ranking
1	Using Appropriate Drone Size	4.19	Strongly Agree	2
2	Malaysian Construction Industry Development Board (CIDB) Initiative	3.975	Strongly Agree	4
3	The government of Malaysia encourages the private sector to innovate in the usage of drone services	4.06	Strongly Agree	3
4	Battery Replacement	4.206	Strongly Agree	1

4.2 Discussion

This analysis finds the use of drone technology for project monitoring on construction sites. This study might also show the degree to which drone technology has been adopted in the construction industry since its inception a few years ago. This technology is still in its development and its usage in the construction industry will continue to develop in the future. In addition, this study reveals the factors that impede the usage of drones on construction sites, such as drone operation control, small battery capacity, the number of potential accident risks, and challenges associated with commercial drone flight.

Based on summary Table 2, it can conclude that all the respondents are having the same problems on drone operation control in the construction sites in Melaka. The majority of the respondents are agreed on the consent level with all the problems stated. From the table 2, drone operation control is the most factor aspect that the respondents responded. It follows with small battery capacity and number of potential risks. On the other hand, the least factor is issues associated with commercial drone flight.

As the primary tasks of drones are photography, video, monitoring activities, and mapping of building sites with a very broad area, drone operators must also be informed about the usage of drones and possess the ability to circumnavigate construction sites using drones. Drones must be operated by categorize pilots based on (Tatum & Liu, 2017) remark noting that the United States Federal Aviation Administration (FAA) has announced new rules regarding the granting of Pilot Remote Control Certificates and defined the requirements to category drones for commercial usage in August 2016. There are limits on the use of drones in the airspace of Malaysia. Small Unmanned Aircraft System, Small Unmanned Surveillance Aircraft, and Unmanned aircraft System more than 20 Kilograms are the three classifications of drones in Malaysia. According to the Malaysian Aviation authority Malaysia (CAAM), approval from the landowner must be obtained prior to applying for a permit. Owners of drones are recommended to adhere by the rules and regulations for operating them with a valid government licence. Without the owner's permission, drones are not permitted to fly over private estates (Majeed *et al*., 2021). According to Lidynia *et al*,. (2017), the level of tolerance between countries regarding the use of drones weighing less than 150kg varies, with some countries being less strict than others. This is because each country has its own rules and laws regarding the use of drones, in addition to the European Union's guidelines regarding the use of drones weighing more than 150kg.

In addition, steps that can be taken to increase the use of drone technology in the future can be obtained, such as the use of an appropriate drone size, the Malaysian Construction Industry

Development Board (CIDB) Initiative, the Malaysian government's encouragement of private sector innovation in the use of drone services, and battery replacement. This can assist in increasing and expanding the use of drone technology in the construction industry.

Based on summary Table 2, the highest top three rankings that respondent chose is battery replacement. The main step that can be taken to overcome the factor that hinders the use of drones for project monitoring in construction sites is battery replacement.

Monitoring battery health and equilibrium to lessen the risk of. If further flying time is needed to continue work, a replacement battery is required failure (Opfer & PE, 2014).The hovering, wireless connections, data transfer, and picture processing of drones are often powered by batteries. Due to power constraints, a decision must be made on whether data and image processing should be performed onboard in real-time or offline (Shahmoradi, Talebi, Roghanchi, & Hassanalian, 2020). This should be raised to extend flight duration (Irizarry *et al*., 2012). The short flight duration reduces the effectiveness of the drone. Thus, the activities that can be performed with a drone are restricted. Frequently, it is important to replace the battery to extend flight time.

It is not difficult to implement drone technology in the construction sector, and it can be advantageous for construction industry users. Drones facilitate the reporting of progress. However, the drone pilot must be knowledgeable about the drone and routinely service it. Lack of technical understanding accounted for the majority of the obstacles faced by drone users in the construction industry. Before using a drone, the persons in charge of its operation must have the necessary knowledge to maximise its potential. The functional versatility of drone technology can further enhance the quality of a construction project activity. This programme can also increase the quality of a building project by utilising technology that can produce higher-quality construction outcomes.

5. Conclusion

In conclusion, this analysis finds the use of drone technology for project monitoring on construction sites. This study might also show the degree to which drone technology has been adopted in the construction industry since its inception a few years ago. This technology is still in its development and its usage in the construction industry will continue to develop in the future. In addition, this study reveals the factors that impede the usage of drones on construction sites, such as drone operation control, small battery capacity, the number of potential accident risks, and challenges associated with commercial drone flight. In addition, steps that can be taken to increase the use of drone technology in the future can be obtained, such as the use of an appropriate drone size, the Malaysian Construction Industry Development Board (CIDB) Initiative, the Malaysian government's encouragement of private sector innovation in the use of drone services, and battery replacement. This can assist in increasing and expanding the use of drone technology in the construction industry.

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