Jurnal Kejuruteraan 35(3) 2023: 657-669
https://doi.org/10.17576/jkukm-2023-35(3)-13

Earthwork Volumetric Estimation Via Unmanned Aerial System Application: Perception From Penang Contractors

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Received 5 August 2022, Received in revised form 31 October 2022
Accepted 3 December 2022, Available online 30 May 2023

ABSTRACT

Despite the geospatial potential of Unmanned Aerial System, its application in the construction industry is still at an early stage and limited exposure on the application. A survey was conducted to identify the factor of utilization level, their difficulties, as well as the perception associated with this technology. Responses from the Penang Contractors showed that the most common utilization factor is cost expectancy and limited payload and battery life, sensitivity to weather, as well as large volume of the generated data and data loss, as difficulties to utilizing UASs in earthwork volumetric estimation during preliminary stage, deployment stage and post-deployment stage respectively. This study also used a qualitative technique, in which data were gathered via interviews with a contractor. Participant consider all variables affecting the perception except project requirements. By understanding UAS utilization in construction, this study offers a pathway for researchers and professionals to investigate utilization factors, difficulties, and perceptions that may have the most impact on Malaysia's construction industry. These barriers to UAS utilization in Malaysia's construction industry will not preclude its use. However, government assistance is critical in encouraging the use of UAS and increasing public awareness in the construction industry.

Keywords: Unmanned aerial system; earthwork volumetric estimation; perception of contractors

INTRODUCTION

In recent years, the advancement of technology has seen surveying industry to adopt a significant change in modern technological development creating innovations for measuring and computing elements of the earth surface. Most construction projects now depend solely on conventional ground-based survey techniques to gather data for volumetric estimation of constructing material (Kelsey 2017). Until recently, many contractors would engage a surveyor to do the traditional technique of estimating earthwork volume (Arango & Morales, 2015). With the significance of volume estimation, conventional approaches should have an improvement and it is critical to continually adapt to the ever-changing world of technology. Unmanned Aerial System (UAS) are one of the innovations that has become attractive as an option for surveying application in civil engineering field. Gupta et al. (2019) described UAS as a system composed of many components such as air vehicles and other related equipment that fly autonomously without the presence of human operator. According to Ajayi and Palmer (2020) technological innovation has broadened the application of UAS from its typical military use, which was its original use, to a data capture tool for environmental monitoring, modelling, and management.

Despite their vast potential and vigorous advocacy, UAS UASs have yet to be extensively implemented throughout the construction industry due to various types of difficulties (Dupont et al. 2017). These difficulties are grouped into three categories by: difficulties during preliminary stage, difficulties during deployment stage and difficulties during post-deployment stage. The difficulties during preliminary stages deals with the shortcoming associated with the management and owner support, UASs general costs, limited payloads, restrictive regulations, pilot and flight certification, insurance and privacy issues, as well as flight planning (Albeaino & Gheisari 2021). Next, the difficulties during deployment stage are associated with public safety, accidents, inferences with project activities, sensitivity to weather, limited flight duration and failure of GPS signals and inefficient flight paths. Lastly, the difficulties during post-deployment stage deals with large volume of the generated data and data loss, low resolution of the captured images, photogrammetry challenges, software suitability, data quality and cleaning, as well as validation of results.

There are relatively few survey questionnaires available that evaluate the practical use of UAS technology in construction from the viewpoint of industry players (Albeaino et al. 2019). Kim et al. (2016) designed a questionnaire to obtain responses from construction experts about a variety of UAS-related issues that might impact this technology's effectiveness in safety management activities (Ajayi & Palmer 2020). Additionally, the research identified many advantages and challenges to UAS integration in safety control activities and prioritized them based on participant feedback. Other more recent questionnaires with a larger population sample examined the current and future potential use of UASs in construction, as well as the risks and benefits associated with their deployment in this domain (Hubbard and Hubbard 2017; Tatum and Liu 2017). This is crucial, since insights from this relevant consumer would correctly represent the current level of UAS technology, as they would come from individuals who have used or are likely to utilize this technology in the future.

Controversially, the deployment of the UAS within the construction industry is relatively new and yet limited to only a few application operations (Siebert & Teizer 2014). The usage of UAS applications are still infancy among local practitioners. Rahman et al. (2017) discovered that UAS is not as widespread across the nation as previously imagined. In reality, the construction sector has been hesitant to embrace new technologies. Understanding which technology to utilize for various work responsibilities might be difficult in such a conventional method. Similar concerns often cause UAS in Malaysia's construction business to be disregarded, owing to the fact that this technology is still in its infancy in Malaysia (Ida 2017). Furthermore, when it comes to implementing changes, the Malaysian construction sector are still accustomed to a top-down approach. The difficulty in persuading construction industry experts who were accustomed to using traditional methods of operation to adopt new technology was due to the fact that those experts had been accustomed to using traditional methods for many years and were unwilling to learn new things to complete the same task (Jansen et al. 2015). These limitations may unnecessarily hinder the use of UAS in Malaysia's building sector.

This paper focus on UAS as a device to improve the construction work performance specifically for earthwork volumetric estimation. The objectives of study are 1) evaluating the factor of utilization level of UAS in estimating the earthwork volumetric; 2) identifying the difficulties in utilizing UAS in earthwork volumetric estimation and 3) investigate the respondents' perception on the concept of UAS utilization in earthwork volumetric estimation. The contribution of this research is to assist academic and industry experts in better understanding the utilization and its concept, ultimately paving the way for a more effective UAS integration in the construction domain. Figure 1 below shows the formulation of research conceptual framework.

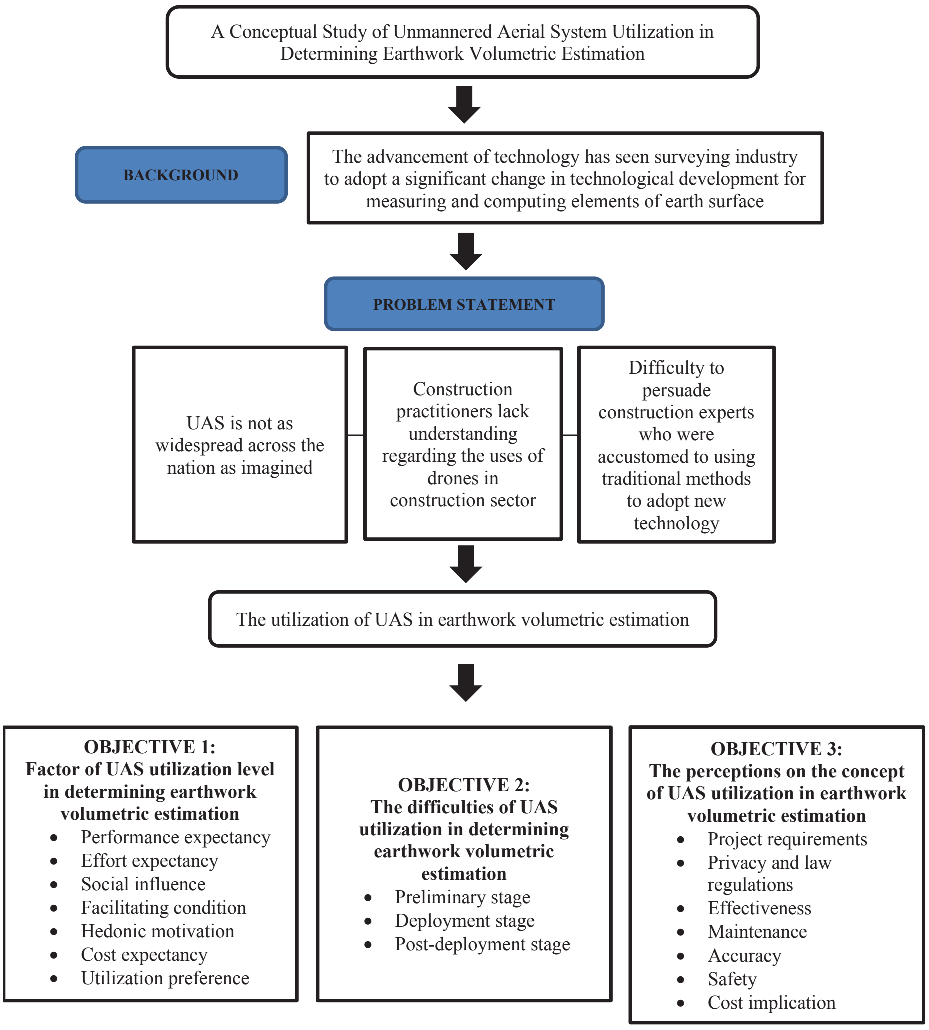

FIGURE 1. Formulation of Research Conceptual Framework

METHODOLOGY

RESEARCH DESIGN

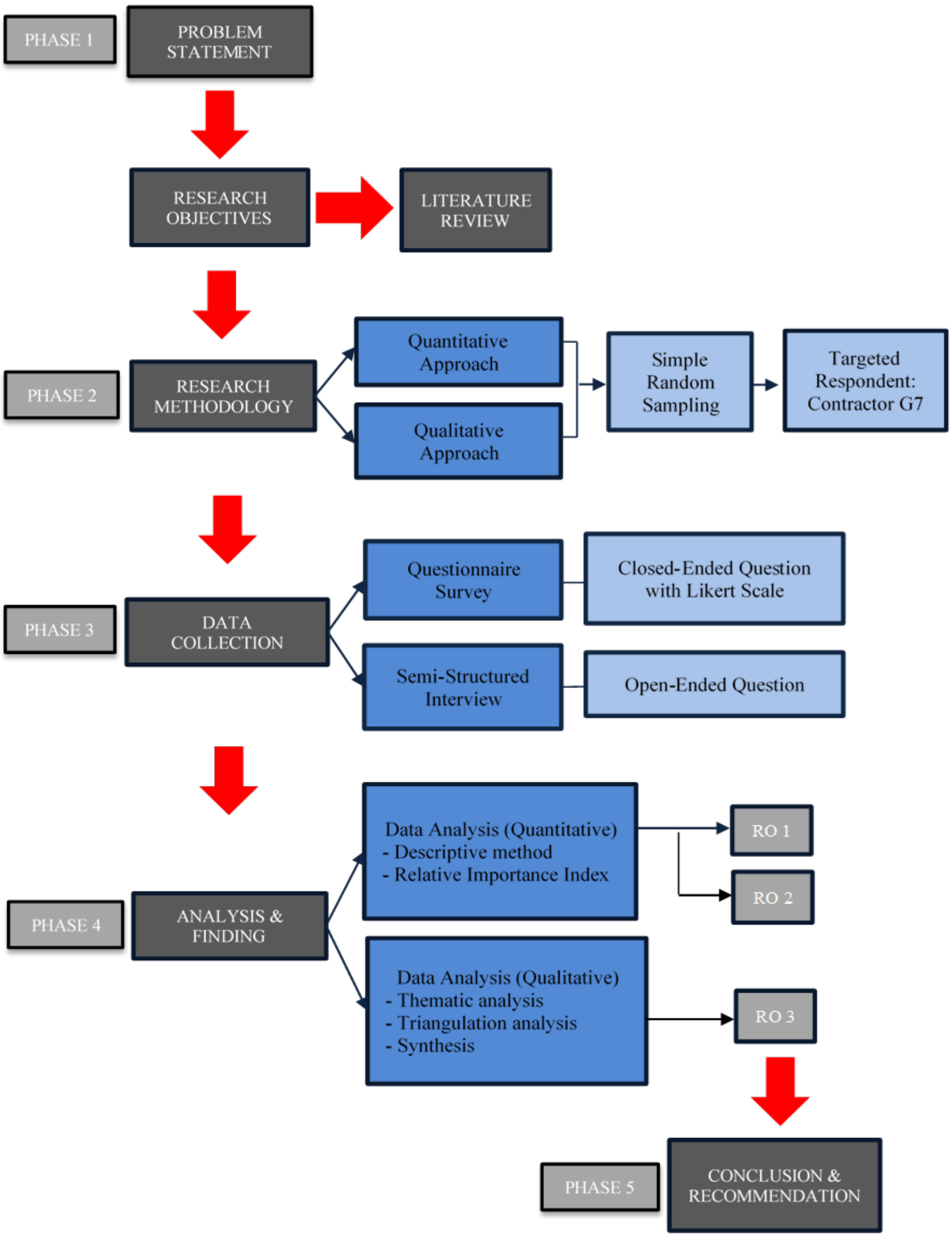

FIGURE 2. Research Methodology Flowchart

QUESTIONNAIRE SURVEY

This research employed two methods of data collection. For quantitative method, questionnaire survey were used. Closed-ended questionnaire were distributed to contractors grade 7 in Penang to assess the factor of utilization level of UAS using a five point likert scale. A total of 72 respondents out of 226 have participated in answering the questionnaire survey. Prior to its administration, the survey was thoroughly evaluated and piloted among industry professionals and chosen university academics for relevancy and validity assessment. In this study, the targeted respondent for pilot study are same as targeted respondents for the actual survey. A phone call to the targeted responses was held to ensure that the questionnaire was distributed and to aware the targeted respondent to fill up the questionnaire. Respondents were requested to answer the questionnaire within one month time frame. In collecting the relevant data, stratified random sampling technique is used and the population of this study is comprised on grade 7 contractor that register with Construction Industry Board Malaysia (CIDB).

SEMI-STRUCTURED INTERVIEW

In order to enhance the data collection, mix method were used by conducting both exploratory interview and involve with questionnaire. Semi-structured interview were conducted with one participant which is a contractor grade 7 that has an more than 10 years epxerience handling volumetric estimation via UAS, also experience handling large amount of infrastructure project which more than MYR 15,000,000.00 to answer the interview questions regarding the perceptions of UAS utilization in earthwork volumetric estimation based on his wide experience in related field in the Malaysian Northern Region. The semi structured interview, which lasted 25 minutes and was audio-recorded with the participants' consent, was done over the phone. Afterwards, the interview was transcribed and analysed using a thematic analysis method. This approach comprises coding, thematization, synthesising, and analysing data, and it is based on earlier qualitative investigations (Che Omar et al. 2020). Interview details presented in Table 1:

TABLE 1. Interview Details

Variable	Details
Expert panel	G7 contractor
Gender	Male
Medium of Interview	Phone call
Duration	20 minutes

Validity and Reliability

To obtain content validity index, the validity was confirmed with the academicians before the questionnaire were distributed. The questionnaire was checked by Rater 1 and Rater 2 and were rated according to scale.

The background for Rater 1 is lecturer at UniMAP and the background for Rater 2 is an engineer from Pulau Pinang. Table 2 shows the results of content validity index.

TABLE 2. Background of Panel Expert

Expert Panel	Organisation
Rater 1	Lecturer in UniMAP
Rater 2	Engineer

According to Davis (1992), the acceptable CVI values should be at least 0.80 for two number of experts. Based on the above calculation, we can conclude that I-CVI, S-CVI/Ave and S-CVI/UA meet satisfactory level, and thus the scale of questionnaire has achieved satisfactory level of content validity. Table 3 shows the content validity index for this study.

TABLE 3. Content Validity Index

Variables	Rater 1	Rater 2	Number of Agreement	I + CVI	UA
Factor of utilization level of UAS					
Performance expectancy	1	1	2	1	1
Effort expectancy	1	1	2	1	1
Social influence	1	1	2	1	1
Facilitating condition	1	1	2	1	1
Hedonic motivation	1	1	2	1	1
Cost expectancy	1	1	2	1	1
Utilization preference	1	0	1	0.5	0
			S-CVI/Ave	0.93	
			S-CVI/UA		0.86
Difficulties in utilizing UAS					
Preliminary stage	1	1	2	1	1
Deployment stage	1	1	2	1	1
Post-deployment stage	1	1	2	1	1
			S-CVI/Ave	1.0	
			S-CVI/UA		1.0

RELIABILITY

Cronbach's alpha has been recognised as one of the most important and widely used statistics in test development and use research (Cortina, 1993). According to Taber (2018), the ideal Cronbach's Alpha value is 0.7, 0.8 is better, and 0.9 is the best. A Cronbach's Alpha score greater than 0.7 is sufficient to assess the instrument's reliability or internal consistency. Based on Table 4 below, Cronbach's Alpha for all variables exceeds 0.7. This data was collected through questionnaire and pilot study with 30 respondents. As a result, all of the variables are acceptable and can be included in the final survey without changing any of them.

TABLE 4. Reliability Coefficient for Variables

Variables	Number of the original item	Cronbach's Alpha	Scale	Rating
Utilization level of UAS	**21**	**0.973**	**≥ 0.9**	**Excellent**
Performance Expectancy	3	0.853	0.80 – 0.89	Good
Effort Expectancy	3	0.986	≥ 0.90	Excellent
Social Influence	3	0.836	0.80 – 0.89	Good
Facilitating Condition	3	0.943	≥ 0.90	Excellent
Hedonic Motivation	3	0.990	≥ 0.90	Excellent
Cost Expectancy	3	0.994	≥ 0.90	Excellent
Utilization Preference	3	0.800	0.80 – 0.89	Good
Difficulties in utilizing UAS	**20**	**0.997**	**≥ 0.90**	**Excellent**
Preliminary stage	8	0.991	≥ 0.90	Excellent
Deployment stage	6	0.989	≥ 0.90	Excellent
Post-deployment stage	6	0.999	≥ 0.90	Excellent
Perception in utilizing UAS	**7**	**0.921**	**≥ 0.90**	**Excellent**
Project requirements	1	0.723	0.70 – 0.79	Acceptable
Privacy and law regulations	1	0.940	≥ 0.90	Excellent
Effectiveness	1	0.939	≥ 0.90	Excellent
Maintenance	1	0.918	≥ 0.90	Excellent
Accuracy	1	0.939	≥ 0.90	Excellent
Safety	1	0.940	≥ 0.90	Excellent
Cost implication	1	0.827	0.80 – 0.89	Good

NORMALITY

For each variable in this study, the values from the Skewness and Kurtosis tests are used to infer the sample's normality. The skewness value indicates the symmetry of the distribution, while kurtosis indicates the "peakedness" of the distribution (Pallant, 2013). According to Sekaran (2003), values that fall within the range of -2 to +2 for the Skewness test, and -3 to +3 for the Kurtosis test are considered within the normal range. Therefore, the normality of the sample is appropriate. Details of the normality test findings are shown in Table 5.

TABLE 5. Statistical Normality Tests for Scale Data

Variables	Descriptive	Statistic
Factor of Utilization Level of UAS	Skewness	0.01
	Kurtosis	-1.22
Difficulties in Utilizing UAS	Skewness	-0.56
	Kurtosis	-1.45
Perception of Utilizing UAS	Skewness	-1.28
	Kurtosis	1.14

DATA SCREENING AND ANALYSIS

A total of 72 respondents were collected and then screened to exclude incomplete responses. Based on the data collected through the distribution of questionnaires, male respondents are significantly outnumbered female respondents, accounting for 68.1 percent as against 31.9 percent, respectively. Next, the majority of the respondents are from the age group of 20 to 29 years old (51.4%) and 30 to 39 years old (31.9%). 16.7 percent were from the group of 40 to 49 years old while there is none from the age group of 50 years old and above. In terms of education level, the majority of the respondents have bachelor's degree as their educational qualification achieved (66.7%), followed by diploma (20.8%) and master degree (12.5%). There is none respondent from certificate and doctorate level who has participate in this survey. Table 6 shows the demographic profiles of the respondent (N=72).

TABLE 6. The Demographic Profiles of the Respondent (*N*=72)

			Frequency, *n*	Percentage, %
Gender	Male		49	68.1
	Female		23	31.9
		Total	72	100
Age	20 – 29 years old		37	51.4
	30 – 39 years old		23	31.9
	40 – 49 years old		12	16.7
	50 years old and above		0	0
		Total	72	100
Education level	Certificate		0	0
	Diploma		15	20.8
	Bachelor's degree		48	66.7
	Master degree		9	12.5
	Doctorate		0	0
		Total	72	100

For the section of company's profile, most of the respondents are from the Northeast Penang Island (30.6%) and followed closely by the respondent from Central Seberang Perai (29.2%). From the company's experience group, most of the company has a 15 years and above experience with 70.8 percent, followed by 10 to 15 years with 16.7 percent and 5 to 10 years with 12.5 percent, while there is none representative from company that has below 5 years' experience. Table 7 shows the company's profile of the respondent (N=72).

TABLE 7. The Company's Profile of the Respondent (*N*=72)

			Frequency, *n*	Percentage, %
Company's location	North Seberang Perai		8	11.1
	Central Seberang Perai		21	29.2
	South Seberang Perai		11	15.3
	Northeast Penang Island		22	30.6
	Southwest Penang Island		10	13.9
		Total	72	100
Company's experience	Below 5 years		0	0
	5 – 10 years		9	12.5
	10 – 15 years		12	16.7
	15 years and above		51	70.8
		Total	72	100

RESULT AND DISCUSSION

FACTOR OF UTILIZATION LEVEL

Table 8 below shows the results of a descriptive analysis of the factor of utilization level of Unmanned Aerial System (UAS) in estimating the earthwork volumetric among contractors grade 7 in Penang. The majority of respondents agree with the statement because mean analysis scores more than "3.00" for all the variables. The finding shows that cost expectancy was in the highest rank with mean value of 4.38 and standard deviation 0.701. Respondents are aware of the acquisition and maintenance costs involved in UAS utilization. This indicate that cost expectancy is highly influencing the UASs utilization level.

Effort expectancy were ranked as second place with mean value of 4.36 and standard deviation of 0.678. Under this variable, most respondent agrees that UAS will provide flexibility in a construction project. They believe real time (live) images in UAS can be use to the maximum extent. Utilization preference were at the third place with the mean value of 4.32 and standard deviation of 0.709. According to the survey, respondents agree that the usage of UAS in their company will provide flexibility in construction activity compared to the conventional method. Lastly, social influence was ranked as the last place with the mean of 3.53 and standard deviation of 0.934. Under this variable, most respondent less likely agrees that the advancement of construction technology influences their company to utilize the UAS. Social influence implies that others have an effect on an individual's accepting behaviour. The subjective norm notion is the primary root construct of this social influence variable (Ghalandari 2012).

TABLE 8. Descriptive Analysis for Factor of Utilization Level

Variables	Mean	Std. Deviation	Rank	Mean Value
Performance Expectancy	4.25	0.765	6	Good
Effort Expectancy	4.36	0.678	2	Good
Social Influence	3.53	0.934	7	Good
Facilitating Condition	4.26	0.769	4	Good
Hedonic Motivation	4.26	0.712	5	Good
Cost Expectancy	4.38	0.701	1	Good
Utilization Preference	4.32	0.709	3	Good

DIFFICULTIES IN UTILIZING UAS

The descriptive analysis of the variables for the difficulties at preliminary stage shows that most respondent agreed that acquisition, setup, operating, and maintenance costs (RII = 0.675) is the least influence difficulties. The initial expenses of acquiring UAS are very costly at the moment, but will decrease as technology progresses, particularly in the construction industry. However, UAS are cost effective in the long term owing to their low operating and maintenance costs (Gortolev, 2014). Next, limited payload and battery life (RII = 0.953) are the most influence difficulties. Various types of payload can be mounted on the UAS platform depending on the required type of data (e.g., image, video, audio) and specific application. According to Grind Drone (2017), UAS have a shorter service life. Thus, one of the most significant problems for UAS applications is the short flight duration provided by the small battery.

Lastly, privacy issues (RII = 0.936) are chosen as the least influencing difficulties at preliminary stage. Herrmann (2016) identified privacy as a possible factor associated with the use of UASs on work sites. Despite gaining authorization to operate UASs on-site from various project organisations (e.g., the owner, insurance providers), privacy problems may arise from adjacent properties, the residential community, or pedestrians who did not necessarily consent to their movements being observed (Herrmann 2016) as per Table 9.

TABLE 9. Descriptive Analysis of Difficulties at Preliminary Stage

Difficulties at Preliminary Stage	RII	Rank
Limited payload and battery life	0.953	1
Owner and management support	0.950	2
Insurance issues	0.950	3
Requirement of certifications for pilot and flight	0.947	4
Restrictive regulations	0.944	5
Flight planning	0.942	6
Privacy issues	0.936	7
Acquisition, setup, operating, and maintenance costs	0.675	8

The results shown for difficulties at deployment stage, the findings reveal sensitivity to weather (RII = 0.956) as the most influencing difficulties. Sensitivity to weather such as inclement weather, lighting conditions, sunlight reflectance, and wind speed, could severely affect the aerial platforms' performance, the quality of the recorded data, as well as the flight operation and safety (Herrmann, 2016). Next, interferences with project activities (RII = 0.953) are the second most influencing difficulties. These aspects should be considered carefully since they have the ability to complicate the process and create exceedingly hazardous conditions for employees and other construction entities on-site (Finn and Wright 2012). Lastly, public safety (RII = 0.936) is chosen as the least influencing difficulties at deployment stage. Additionally, respondents expressed considerable worry about the increased safety risks connected with the use of UASs in construction, seeing this as a difficulty to UAS technology utilization. Members of the flight crew (e.g., pilots and observers) should have a thorough grasp of the safety risks connected with the use of UASs on construction sites (Herrmann 2016) as per Table 10.

TABLE 10. Descriptive Analysis of Difficulties at Deployment Stage

Difficulties at Deployment Stage	RII	Rank
Sensitivity to weather	0.956	1
Interferences with project activities	0.953	2
Limited flight duration	0.953	3
Failure of GPS signals and inefficient flight paths	0.953	4
Accidents	0.950	5
Public safety	0.936	6

As for the difficulties at post-deployment stage, the findings reveal large volume of the generated data and data loss (RII = 0.956) as the most influencing difficulties. Team members should also be familiar with data extraction and processing techniques to use the collected data for their specific tasks or decision makings. The loss of huge amounts of data is a serious problem in wireless transmission platforms, where data loss may range between 30 and 50 percent (Yang and Nagarajaiah, 2017). Next, low resolution of the captured images (RII = 0.953) are the second most influencing difficulties. Janssen (2015) discovered that while drone flight can be controlled more easily, a good video feed requires collaboration between two people. There might be a chance that images captured by UAS may have poor resolution. This will lead to inadequate information for analysis (Li et al. 2016). Lastly, software suitability (RII = 0.947) is chosen as the least influencing difficulties at post-deployment stage. There are various UAS-related applications such as Pix4D®, DroneDeploy®, Site Scan®, etc. Their prevalence in the construction area might be attributed to their variety of features and compatibility with a variety of UAS models and other software programmes (Gheisari & Esmaeili, 2019). UASs mostly depend on the embedded software tools. These tools are generally used to operate the UAS vehicles, collaborate with other members of the UAS team, analyse photos, and generate 3D models (Siebert & Teizer, 2014) as per Table 11.

TABLE 11. Descriptive Analysis of Difficulties at Post-Deployment Stage

Difficulties at Post-Deployment Stage	RII	Rank
Large volume of the generated data and data loss	0.956	1
Low resolution of the captured images	0.953	2
Photogrammetry challenges	0.953	3
Validation of results	0.953	4
Data quality and cleaning	0.950	5
Software suitability	0.947	6

RESPONDENTS' PERCEPTION ON THE CONCEPT OF UAS

The respondent perception variables that was conducted to undergo triangulation analysis in order to determine whether the perception of respondent is reliable. In this triangulation analysis, the data from semi-structured interview was compared to the questionnaire. Table shows the comparison between descriptive data and exploratory data. In this triangulation study, the semi-structured interview is being compared to the questionnaire. The semi-structure interview is done by asking an expert panel a validation content on questionnaire in order to compare the answer with quantitative data shown in Table 12.

TABLE 12. Triangulation Analysis of Perception on the Concept of UAS

Code	Variable	Descriptive Data		Exploratory Data
		Mean	Std. Dev	Responses
PP1	Project requirements	4.07	0.909	X
PP2	Privacy and law regulations	4.67	0.557	/
PP3	Effectiveness	4.65	0.561	/
PP4	Maintenance	4.65	0.561	/
PP5	Accuracy	4.65	0.561	/
PP6	Safety	4.67	0.557	/
PP7	Cost implication	4.60	0.597	/

Note: (/) Significant influence; (X) Low influence

The majority of respondents disagree with the first perception stated in the questionnaire. Project requirements has the mean value of 4.07 and were significantly influence the perception of utilization. This is supported by interview where the participant strongly agrees that utilization of UAS will not influence the project requirement because it will depend on the specific types and requirements of the project. Also, participant believe that even the company has utilizing UAS, it will not be necessary to utilize it in every project as shown in Table 13.

TABLE 13. Perception on Project Requirements

Variable 1	Project Requirements
Question 1	Did your company will make it compulsory to utilize UAS in determining earthwork volumetric estimation for every upcoming project?
Answer	*"No, because every project is depending on specific types and requirements. Not all project is required to carry out earthwork process. Thus, it will not be necessary to utilize UAS in every project".*

The privacy and law regulations has the mean value of 4.67. As a result of the interview, the participant agree that privacy and law regulations are highly influencing their perception in utilization of UAS. Participants' assume that professional and certified pilot is required, also mandatory to follow government procedure. Thus, this variable is fairly high influence according to the participant perception based on Table 14.

TABLE 14. Perception on Privacy and Law Regulations

Variable 2	Privacy and law regulations
Question 2	What is your opinion regarding the responsibility and legal challenge when utilizing UAS?
Answer	*"Company's need to hire professional and certified pilot for UAS operation. Need to follow government policies, rules and regulations".*

The effectiveness is ranked has the mean value of 4.65. As a result of the interview, the participant agree that effectiveness is highly influencing their perception in utilization of UAS. Participant believe that environmental condition can be the major reason why they are avoiding to utilize UAS technology. Environmental conditions such as inclement weather, lighting conditions, sunlight reflectance, and wind speed may have a detrimental influence on aerial platform performance, data quality, flight operation, and safety (Gheisari & Esmaeili, 2019) based on Table 15.

TABLE 15. Perception on Effectiveness

Variable 3	Effectiveness
Question 3	What is your opinion regarding the effectiveness of UAS?
Answer	*"UAS is a technology that can be affected by various environmental condition even with the slightest drizzle rain and strong wind, UAS operation can be affected".*

The maintenance has the mean value of 4.65. As a result of the interview, the participant agree that maintenance is highly influencing their perception in utilization of UAS. Participant believe that UAS required regular and specialised maintenance, moreover, the device and payloads should be up-to-date and able to sustain large volume of generated data. This include the limitation on the capabilities of equipment. The load carriage capacity of UAVs is significantly low. This will limit the aerial capability and their capacity in carrying various payloads (Siebert & Teizer, 2014) based on Table 16.

TABLE 16. Perception on Maintenance

Variable 4	Maintenance
Question 4	What is your opinion regarding the maintenance of UAS?
Answer	*"UAS required regular and specialised maintenance, moreover, the device and payloads should be up-to-date and able to sustain large volume of generated data".*

The accuracy has the mean value of 4.65. As a result of the interview, the participant agree that accuracy is highly influencing their perception in utilization of UAS. Participant believe that UASs can be used with a wide range of modern software and hardware components to gather and create extremely accurate data for quality assessments (Gheisari and Esmaeili 2019). Users must explore the software tools used by industry practitioners on construction jobsites based on Table 17.

TABLE 17. Perception on Accuracy

Variable 5	Accuracy
Question 5	What is your opinion regarding the accuracy of UAS?
Answer	*"Company's need to hire specialist to analyse the data. Data captured by UAS will require software and expert to validate the accuracy".*

The safety has the mean value of 4.67. As a result of the interview, the participant agree that safety is highly influencing their perception in utilization of UAS. Participant point out that UAS can only be used over a large area with no other interruptions to avoid collisions. Operating UAS on construction site elevate safety risk for on-site workers (Kim et al. 2016) based on Table 18.

TABLE 18. Perception on Safety

Variable 6	Safety
Question 6	What is your opinion regarding the safety of UAS operation?
Answer	*"UAS can only be used over a large area with no other interruptions to avoid collisions".*

The cost implication has the mean value of 4.60. As a result of the interview, the participant agree that safety is highly influencing their perception in utilization of UAS. Participant emphasise that UAS demands high acquisition, operation and maintenance cost, thus, it will affect the financial requirements of the project based on Table 19.

TABLE 19. Perception on Cost Implication

Variable 6	Cost implication
Question 6	What is your opinion regarding the cost implication when utilizing UAS?
Answer	*"UAS demands high acquisition, operation and maintenance cost, thus, it will affect the financial requirements of the project".*

SYNTHESIS OUTCOMES

Triangulation data were used as a different in between finding from questionnaire and semi-structured interview method. Afterward, the data was synthesised in order to make it easier to comprehend and conduct. This synthesis was necessary due to the evident lack of clarity between authors in the literature by settling what truths they have in common. In the end, the synthesis aims to acquired supporting statements from previous authors regarding the variables. Table 20 shows the data synthesis outcomes.

TABLE 20. Data Synthesis for Third Objective

Objectives: To investigate the respondents' views on the concept of Unmanned Aerial System (UAS) utilization in earthwork volumetric estimation.			
Variables	Author	Highlights	Similarities
Project requirements	Jansen et al. (2015)	Acceptance of UAS technology	/
	Yahya et al. (2021)		/
Privacy and law regulations	Herrmann (2016)	Restrictive regulatory	/
	Rahman et al. (2019)		/
Effectiveness	Neil & Shields (2014)	Weather conditions	/
	Bulgakov et al. (2015)		/
	Kacunic et al. (2016		/
Maintenance	Bulgakov et al. (2015)	Technical difficulties	/
	De Agostino et al. (2010)		/
Accuracy	Albeaino et al. (2019)	Data generations	/
	Gheisari and Esmaeili (2019)		/
Safety	Yahya et al. (2021)	Obstacles on construction sites	/
	Amor (2012)		/
Cost implication	Kim et al. (2016)	Acquisition, setup, operating, and maintenance costs	/
	Kumar et al. (2016)		/
	Siebert and Teizer (2014)		/

CONCLUSION

Cost expectancy is highly influencing the UASs utilization level. It is a highly significant input for practitioners' consideration. This factor will cause contractors to hinder this technology as cost is consider as major item in bussiness. In order to enhance the utilization of UAS, Malaysian government should take appropriate measure. Comprehensive initiative should be applied in order to interact UAS companies to expand their business here. Government need to further promotes the UAS technology especially to construction sector the same way government promoting the implementation of industrialised building system (IBS) into construction industry. Next, to utilize UAS, all existing difficulties should be identified in order to reassuring the construction practitioners regarding the advantages of this technology. For preliminary stage, the factor that are identified as the most influencing difficulties is acquisition, setup, operating, and maintenance costs. This factor will reduce the interest of construction practitioners to utilize this technology as the preliminary difficulties involve high cost. Due to this, company are advised to reallocate budget and financially prepared to adopt new technology in their company.

In the construction industries, perception is highly influencing the utilization of certain technology. There is a need to expand the factor to add on variety. It is recommended to fill up the gaps in this study. This is due to most of the factors in this study are obtained from the research abroad. By collecting the participant responses, new variables from Malaysia's construction practitioner can be implement for future studies. In addition, given the large applicability of UASs in the construction industry, deeper insights should be analysed to achieve more precise inputs, moreover, another area of investigation should be offered through the findings presented here. An accurate earthwork volumetric estimation is critical for controlling construction costs and improving financial management. Currently, the techniques used to acquire data for volume calculations include the commissioning of a survey team to carry out on-site topographic measurements. However, due to the process of data acquisition that are complex, hence, this study aims to assists construction practitioners to gain a better precision and accuracy related to data acquisition and analysis as well as provides a significant boost in quality and efficiency. Moreover, an accurate earthwork volumetric estimation is critical for controlling construction costs and improving financial management.

UAS applications are consistent with and complement the Malaysian Sustainable Development Goals (SDGs). Drones or UASs have economic applications for humanity and society that have piqued attention, particularly in the context of the 4th Industrial Revolution, and for ambitions toward a digital economy, particularly in developing countries. SDGs has driven a drone centre of excellence; a stakeholder-driven initiative that aims to raise awareness, educate and dispel misunderstanding and misinformation, as well as offer training. Recently, the Nevada Drone Center of Excellence for Public Safety (NDCOE), was established. NDCOE was created with the goal of resolving the challenging UAS industry dilemma of reducing drone intrusions into the National Airspace System (NAS) – one of the most difficult difficulties FAA currently facing. The centre will contribute to the advancement of infrastructure protection and drone detection technologies, as well as the enhancement of air safety and the expansion of air commerce. Additionally, the department will host public seminars to promote and safeguard the public's safety and privacy.

This research is intended to provide more information of UAS technologies for better understanding and recognition. The expected outcomes from this research is to improve the utilization of UAS technology in construction industry specifically for earthwork volume estimation. Hence, this research highlights the conventional methods used to collect earthwork data. Technological advancement in surveying and construction have been accelerating. Therefore, the outcome from this research exposed the application of drones or unmannered aerial system for determining earthwork volumetric estimation in construction industry. When compared to the conventional approach, the new practise of utilising UAS technology provides a significant boost in quality and efficiency. Furthermore, the use of UAS in construction projects would help gaining a better precision and accuracy related to data acquisition and analyses. Thus, by using this technology, it can help reducing the complexity in acquiring spatial data.

In addition, with this study, it can help to support the usage of UAV or drone technology in line with the MDEC's MyDroneTech initiative to enhance the rapid growth of Malaysia's DroneTech industry. Utilizing drones as the emerging technologies are one of the efforts to support the Industry 4.0. Drones are having a significant effect on the emerging Industry 4.0 due to its utility and flexibility in a variety of industrial areas such as civil engineering. Therefore, by addressing the obstacles in utilizing UAS in earthwork volumetric estimation, effective solution can be discovered to overcome the available obstacles. Hopefully, in future, the adoption of UAS technologies in construction industry will increases thus, supporting the government initiative.

ACKNOWLEDGEMENT

The authors would like to thank Universiti Malaysia Perlis (UniMAP) and UiTM Shah Alam, Malaysia for supporting this research.

DECLARATION OF COMPETING INTEREST

None

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