

## Slope Mapping using Unmanned Aerial Vehicle (UAV)

Muhammad Farhan Zolkepli<sup>1</sup>, Norlinda Mohamad Rozar<sup>2</sup>, Mohd Fakhrurrazi Ishak<sup>3\*</sup>,  
Mohamad Hazeem Sidik<sup>4</sup>, Nurul Amira Syuhada Ibrahim<sup>5</sup>, Muhammad Syamsul Imran Zaini<sup>6</sup>

<sup>1,3,5,6</sup>Faculty of Civil Engineering Technology, Universiti Malaysia Pahang, 26300 Kuantan, Pahang, Malaysia

<sup>2</sup>Faculty of Maritime Studies, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Malaysia

<sup>3</sup>Faculty of Entrepreneurship and Business, Universiti Malaysia Kelantan, Pengkalan Chepa, 16100 Kota Bharu, Kelantan

<sup>2</sup>akhrurrazi@ump.edu.my, <sup>3\*</sup>norlinda.rozar@umt.edu

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**Abstract:** This paper discusses the applications of unmanned aerial vehicle (UAV) for slope mapping and also its important parameters including perimeter, area and also volume of certain selected area. With the development of modern technology, the utilization of UAV to gather data for slope mapping becoming easier as it is quick, reliable, precise, cost-effective and also easily to operate. Modern UAV able to take high quality image which essential for the effectiveness and nature of normal mapping output such as Digital Surface Model (DSM) and Digital Orthophoto. This photo captured by UAV will later transfer to commercial software to generate full map of study area. With the help of established software, the measurement of selected study areas can be determined easily which can be considered as the main interest in this study. In addition, another outcome of this study is, this modern method of mapping will be compare to traditional method of mapping which proven to be more effective in term of low costing, low time consuming, can gather huge amount of data within short period of time, low man power needed and almost no potential risk of hazardous effect to man.

**Keywords:** Mediation Effect Firm Performance, Reen Innovation, Firm Value Industry

### 1. Introduction

Nowadays, the instruments uses for data acquisition in geological topography have been rapidly improved. With the development of modern technology, the equipment used to gather all information related to earth surfaces becomes cheaper, smaller, accurate and can gather large number of data within a short period of time (Kumar *et al.*, 2018, Bondarchuk, 2018). Unmanned aerial vehicles ('UAV's) are also known by many other names, such as, unmanned aircraft system ('UAS'), remotely piloted aircraft ('RPA'), micro air vehicle ('MAV') (Beretta *et al.*, 2018).

These devices are light, mobile, easily to operate, completely automated and providing access to almost unavailable study areas. Advances in UAV technology have enabled the acquisition of high-resolution and real-time aerial images for photogrammetry (Park *et al.*, 2019, Turner *et al.*, 2016). An unmanned aerial vehicle (UAV) is normally an aircraft that launches and flies without a human onboard (Eid *et al.*, 2013).

#### 1.1 Traditional Mapping

As suggested by Ibrahim (2020), the first map was found in 2000 BC which is Babylon's clay tablets by Greeks and Romans. After that, the data was collected by surveyors in the field with later drawn to maps by cartographers with printers generating paper maps. The measurement of electronic distance (EDM) explained on how quick it makes proper distance measurements. It also provided way to find the location of the shooting plane, which reduces the amount of measurement needed to produce several type of maps. Table 1 shows the disadvantages of using traditional method of mapping.

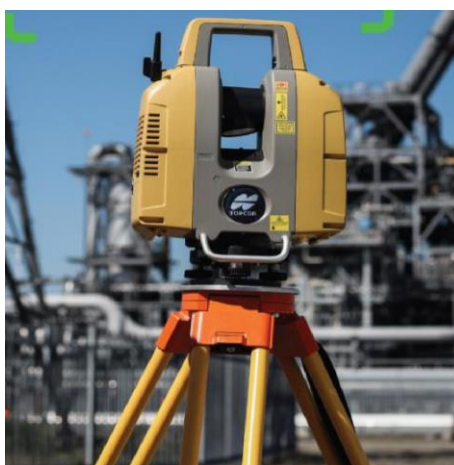
**Table 1.** Disadvantages of mapping using traditional method (Ibrahim, 2020)

Author	Types and Disadvantages
Fitzpatrick (2016)	Manned Aircraft (this method of mapping and volume consume lot of time, cost but less accurate)



Laser Scanning Survey (Expensive, low quality mapping, and time consuming)

Beretta *et al.* (2018)



GPS Point Survey (Inaccurate and not very dense in information)

Sebbane (2018)



Siebert and Teizer  
(2014)

Tachymetry (Theodolite) Surveying (Time consuming, need a lot of workers  
and inaccurate in results)



Rotary Wing UAV  
(High cost and time consuming. Noise level is high and need extreme magnetic field)



Tahar (2011);  
Malehmir *et al.* (2017)

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## 1.2 Mapping Using Unmanned Aerial Vehicle (UAV)

Recently, the use of unmanned aerial vehicle in research study and also commercial term are ending up progressively normal (Kumar *et al.*, 2018). According to Ismail *et al.* (2018), geophysical surveys in mountains and natural terrains are normally challenging due to the site conditions, which may affect the quality of data acquisition. Unmanned aerial vehicle (UAV) or known as drone allow for the effectiveness of monitoring which cover large area of land and infrastructures within a very short time interval compare to conventional techniques (Tziavou *et al.*, 2018).

UAV has developed during the last decades. They operate remotely in the form of small platform, attached completely with camera and available as small or micro aircrafts (Tziavou *et al.*, 2018). UAV photogrammetry provides information used for image stitching. Autopilot system guarantees planned flight path, camera triggered auto-control to take a picture at every waypoint (Kumar *et al.*, 2018). The greatest amount of information is contained in the video signal (Shashev *et al.*, 2015, Panin *et al.*, 2003).

With the help of UAV, the effectiveness of land monitoring together with existing infrastructures can be conducted within a short time period compare to conventional techniques, especially for urgent cases like natural disasters (Greenwood *et al.*, 2016, Tannant *et al.*, 2017). Recent technological developments of unmanned aerial systems (UAS), including unmanned aerial vehicles (UAV) and data processing technologies, lead to extensive use of these techniques in various fields (Scholtz *et al.*, 2012; Colomina and Molina, 2014; Chen *et al.*, 2016; Torok *et al.*, 2020).

The aim of this paper is to obtain slope map of several selected study area located at Pahang Matriculation College, Kuantan, Pahang by using unmanned aerial vehicle UAV or commercially known as drone. Other than that, the measurement of these slopes will be determined such as perimeter, area, volume and more which

considered as the main interest in this study. In addition, this paper also discusses the advantages of slope mapping using UAV compare to traditional method which proven to be the better method. Since this study collaborate with Faculty of Maritime Studies, Universiti Malaysia Terengganu, the authors would like to suggest several mapping around coastal area could be done in the future to study several effect of slope stability at coastal area, embankment at sea area, movement of ship at port and more as suggestion for future research.

## 2. Research Methodology

The study area is located at Pahang Matriculation College, Kuantan, Pahang. The site area consists of different terrain profiles. This site is completely free from any distraction and obstacle on the air for UAV to freely move around. Figure 1 show the map of study area.

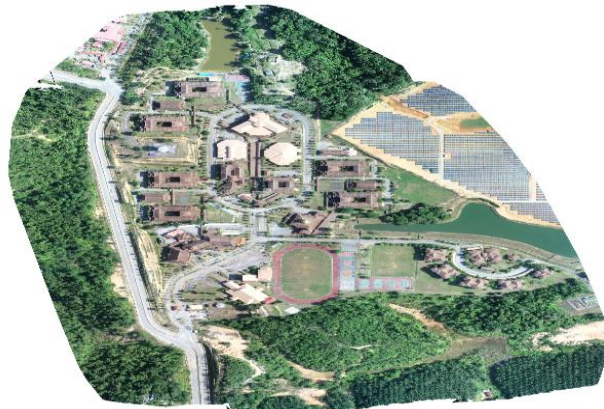


Figure 1. Location of study area

### 2.1 DJI Inspire 2

The DJI Inspire 2 weight around 3.44 kg make it a powerful and high technology drone. This UAV has a speed of 94 km/h which make it pretty impressive. The max ascent speed is 6 m/s in sport mode and the max descent speed is 4 m/s. The length of this UAV is 42.7 cm, with height of 31.7 cm and width of 42.5 cm. DJI Inspire 2 has a maximum transmission distance of 7 km and is capable to deliver both 1080p and 720p video. Figure 2 show the image of DJI Inspire 2. Table 2 show the specification and features of DJI Inspire 2.



Figure 2. DJI Inspire 2

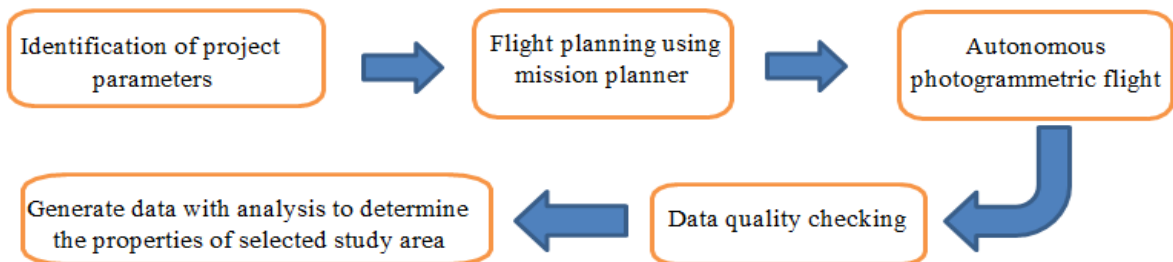
Table 2. Specification of DJI Inspire 2

Parameters	Details
Flight time	25-27 minutes
Speed	94 km/h
Sensory range	30 m
Battery	98 Wh dual battery

Raw video recoding	Yes
Ports	USB and HDMI
Obstacle avoidance system	Yes
Control range	7 km
Video resolution	5.2K and 4K
Live View	1080P
Remote controller frequency	2.4 GHz and 5.8 GHz
Design material	Magnesium aluminium composite shell with carbon fibre arm

## 2.2 Image acquisition

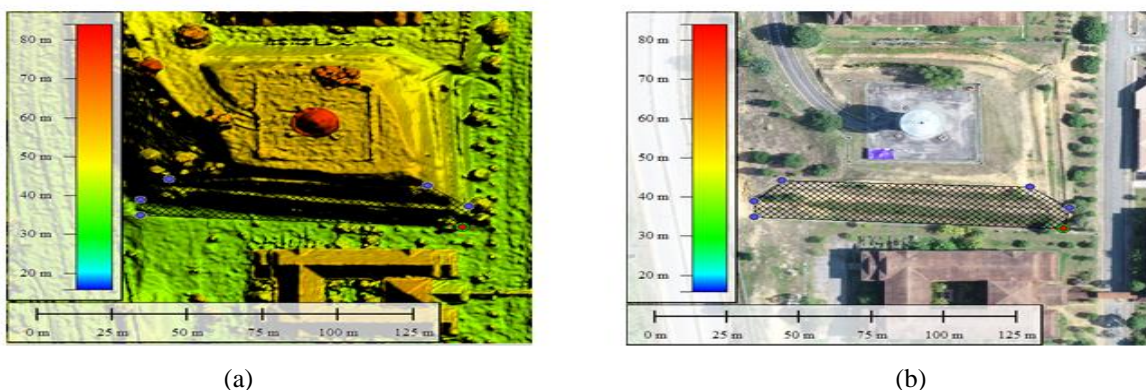
The normal workflow accepted for image acquisition has been used by many researchers and practitioners. Following are the steps for image acquisition as in Figure 3. The results obtained from UAV monitoring will then be transferred into global mapper version 18.1 for further analysis.



**Figure 3.** Workflow for data acquisition

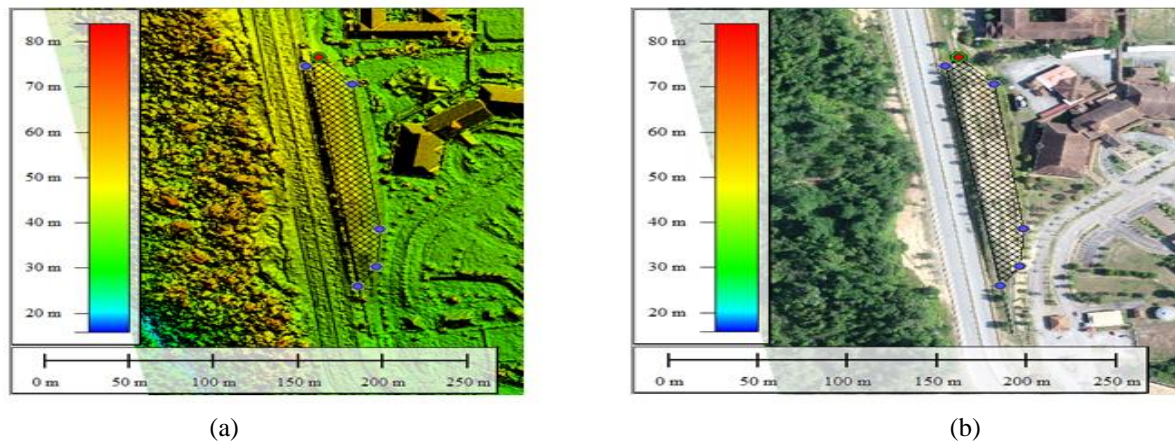
## 3. Results and Discussion

The result of this study is presented in two types of images which are digital ortho photo and digital surface model (DSM). The ground control points (GCP) are not used in this study as it does not give much error for the results obtained. The independent ortho images are used to generate digital ortho photo in photogrammetric process. Figure 4 present the image of area A and Figure 5 show image of area B.



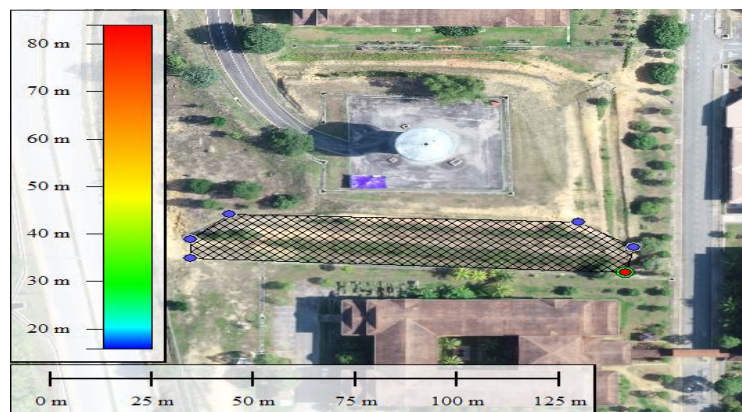
**Figure 4.** (a) Digital surface model (DSM) of area A, (b) Digital ortho photo of area A





**Figure 5.** (a) Digital surface model (DSM) of area B, (b) Digital orthophoto of area B

The application of unmanned aerial vehicle (UAV) not only limited for area mapping, but it can also help to determine the dimension of those areas such as perimeter, area, volume and more. The uses of global mapper software version 18.1 can meet the requirement needed in order to obtain the properties of selected study area. Measurement of area A and B are shown in Figure 6 and Figure 7. The properties of area A and B are presented in Table 3 and 4.



**Figure 6.** Dimension of area A

**Table 3.** Measurement of area A

Measurement	Unit
Total Volume	1303.85 m <sup>3</sup>
Net Volume	138.78 m <sup>3</sup>
Cut Volume	721.31 m <sup>3</sup>
Cut Area	1174 m <sup>2</sup>
Cut Area 3D	1430 m <sup>2</sup>
Fill Volume	582.53 m <sup>3</sup>
Fill Area	910 m <sup>2</sup>
Fill Area 3D	1091 m <sup>2</sup>
Enclosed Area	2078 m <sup>2</sup>
Perimeter	243.52 m

From the table, the total volume of area A is 1303.85 m<sup>3</sup>. The net volume is 138.78 m<sup>3</sup>. The cut volume of area A is 721.31 m<sup>3</sup> whereas its cut area is 1174 m<sup>2</sup>. Besides, the cut area 3D is 1430 m<sup>2</sup>. The amount of fill volume of this area A is 582.53 m<sup>3</sup> while the fill area is 910 m<sup>2</sup>. The total fill area 3D is 1091 m<sup>2</sup>. The enclosed area is 2078 m<sup>2</sup> and the existing parameter is 243.52 m.

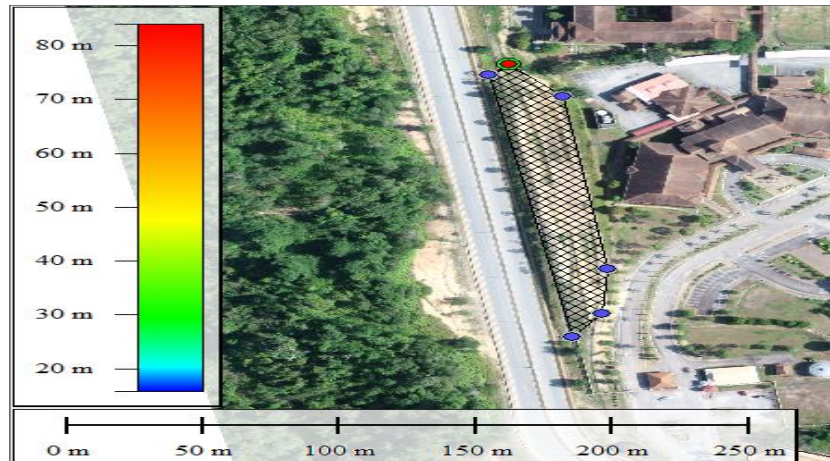


Figure 7. Dimension of area B

Table 4. Measurement of Area B

Measurement	Unit
Total Volume	3182.48 m <sup>3</sup>
Net Volume	2341.13 m <sup>3</sup>
Cut Volume	2761.80 m <sup>3</sup>
Cut Area	3439 m <sup>2</sup>
Cut Area 3D	3959 m <sup>2</sup>
Fill Volume	420.67 m <sup>3</sup>
Fill Area	634 m <sup>2</sup>
Fill Area 3D	749 m <sup>2</sup>
Enclosed Area	4061 m <sup>2</sup>
Perimeter	243.52 m

From the table, the total volume of area B is 3182.48 m<sup>3</sup>. The net volume is 2341.13 m<sup>3</sup>. The cut volume of the area B is 2761.80 m<sup>3</sup> whereas its cut area is 3439 m<sup>2</sup>. Besides, the cut area 3D is 3959 m<sup>2</sup>. The amount of fill volume of this area B is 420.67 m<sup>3</sup> while the fill area is 634 m<sup>2</sup>. The total fill area 3D is 749 m<sup>2</sup>. The enclosed area of area B is 4061 m<sup>2</sup> and the existing parameter is 243.52 m.

Table 5 shows the comparison of slope mapping between Unmanned Aerial Vehicle (UAV) and traditional method. First the comparison in term of area scale where unmanned aerial vehicle (UAV) act as aerial photogrammetric technique to effectively generate medium to extra-large scale mapping and other diversified applications especially for a small area which has limited budget and time compare to traditional method which only generate small scale mapping.

The UAV method allows surveyors to do works in a short period of time and required minimum worker or only one worker which proven to be a better method of mapping compare to those suggested by Fatzpatrick (2016) which using manned aircraft; Siebert and Teizer (2014) which using tachymetry (theodolite) surveying techniques and Tahar (2018); Malehmir et al. (2017) which using rotary wing UAVs survey. They stated that this traditional method is more time consuming and required more workers.

This UAV technique is one of the alternatives for a faster way in data acquisition, easy and safe while according to Beretta et al. (2018) using laser scanning; Sebbane (2018) using GPS point survey; Siebert and Teizer (2014) using tachymetry (theodolite) surveying techniques described that those method consume lot of time for data acquisition and processing, much complicated and unsafe to workers because of challenging site due to factor of topography.

UAV-acquired datasets have better resolutions in both temporal and spatial aspects with the high quality, cheaper and impressive level of details in the outputs compare using laser scanning survey method is expensive, generates low-quality products and unimpressive level of details in the outputs (Beretta et al., 2018).

**Table 5.** Comparison of slope mapping using UAV and traditional method

Comparison	Unmanned Aerial Vehicle (UAV) Method	Traditional Method
Area	Medium to extra large	Small
Time consuming	Short	Long
Usability	Easy	Much Complex
Data quality	High	Low
Cost	Cheap	Expensive
Worker	Minimum (one is more than enough)	Maximum (depend on site)
Potential hazard to man	Safe	Unsafe (especially in high and hilly region)
Data acquisition	Fast	Slow

#### 4. Conclusion

From this study, the uses of UAV has proven to be very effective such as low costing, low time consuming, easily to operate and can gather huge amount of data within short time interval for slope mapping. This modern technology will help in research and also commercial works which make work easier and faster. In this study, with the combination of data from UAV and also established software provide researchers with important parameters and information about geological and topography of study area. Other than that, the properties of the study area such as its perimeter, area, volume and more can be obtain precisely. Mapping using UAV prove to give better impact when compare to mapping using previous traditional method.

As suggested by Nurdin et al. (2019); Darwin et al. (2014); Kaamin et al. (2018), coastal mapping using unmanned aerial vehicle (UAV) can be considered very helpful and effective due to challenge face if conducting mapping using traditional method. Due to huge coastal area, normal mapping considered very challenging and for worst may contribute to fatality for those involve in mapping work.

The coastal zone area is the most valuable asset for inland transport mode and waterways of mobility and transport, In Malaysia, to promote and strengthen the inland and waterway in the transport system is by facilitating its integration into intermodal logistics chain by widen the path of the transport. Thus, infrastructure construction and maintenance are highly required. In the requirements, one of the technologies and technical are recommended is by an application of UAV. As discussed above, it was recognised and used for slope mapping in building development and believed by use of it will assist for constructions of roads, railways, bridges, tunnels, terminals, ports, and airports without limiting the geographical area.

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