MULTIDISCIPLINARY APPLIED RESEARCH AND INNOVATION
e-ISSN: 2773-4773

MARI

Vol. 5 No. 3 (2024) 23-32
https://publisher.uthm.edu.my/periodicals/index.php/mari

Application of Unmanned Aerial Vehicle (UAV) in Visual Inspection for Civil Infrastructure at Sekolah Menengah Bandar Maharani, Muar

Nor Shuhada Natasha Rosli, Nur Adlin Sabrina Mohd Akbar, Nurul Qamarina Kamarolzaman, Ahmad Hakimi Mat Nor *, Masiri Kaamin

Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussien Onn Malaysia, Pagoh Education Hub, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author: ahakimi@uthm.edu.my
DOI: https://doi.org/10.30880/mari.2024.05.03.004

Article Info

Received: 01 March 2024
Accepted: 31 July 2024
Available online: 31 December 2024

Keywords

Building Inspection, Unmanned Aerial Vehicle (UAV), JKR Method

Abstract

Building inspection is crucial to comprehending the building's state or the index of flaws so that the building can be used for a longer amount of time. The use of scaffolding and ropes, which produce erroneous results, especially at high elevations, is one of the traditional building inspection techniques that is typically too unsafe, expensive, and time-consuming. The objectives of this study are to use an unmanned aerial vehicle (UAV) to gather data, categorise building faults using the Public Works Department Standard (JKR Standard), and analyse defects in buildings using a UAV. UAVs are also the primary tool utilised in high-altitude inspection research. In the Muar district's SMK Bandar Maharani school building, this study was carried out. The methodology used in this study, specifically the roof portion, uses the Standard Standards of the Malaysian Public Works Department to determine the degree of construction flaws after the location and type are determined from data collected by a drone and through the Pix4D Mapper software. Even at high altitudes, the use of UAVs makes it possible to quickly and clearly detect damage and defects in the structure of structures, and cameras are also used to check buildings in low-altitude areas.

1. Introduction

Building maintenance procedures used in the past are too risky, expensive, and time-consuming and require skilled workers [1]. Building inspection is important to understand the condition of the building structure or defect index [2] so that the building can be used for a longer period. The state of each building must be periodically inspected by researchers in order to gather correct data and ensure user safety.

Using unmanned aerial vehicles (UAVs) can make it easier to generate 3D models of structures since they produce movies and photographs that enable quick and precise data visualisation. An unmanned aerial vehicle (UAV) is an aircraft without a human pilot, crew, or passengers [7]. The project can operate as a different kind of vehicle driven either manually or remotely. As a result of their numerous benefits, UAVs are now frequently used in industry. UAVs can be utilized in a wide range of diverse industries, such as construction, oil and gas refinery inspections, farm monitoring and mapping, and rescue missions.

Drone visual inspection should be utilised as the initial form of building inspection to find any flaws. [1]. In this study, data will be gathered using an unmanned aerial vehicle (UAV), building damage will be analysed using an unmanned aerial vehicle (UAV), and building flaws will be classified using the Public Works

Department Standard (JKR Standard). The application of drones to building inspection in this study, high-altitude photographs of buildings are used, while low-altitude photographs of damage are taken using mobile cameras. Utilising the Malaysian Public Works Department's criteria, the data collected is analysed to evaluate the degree of damage. The Bandar Maharani SMK Hall building in the Muar district was selected as the study site due of numerous problems that can be readily noticed. The UAV will take pictures while it circles the area of the building shown in Fig. 1.

Fig. 1 *Plan view through google earth [4]*

1.1 Unmanned Aerial Vehicles (UAV)

The Hassellad LID-20c camera on the Mavic 2 Pro UAV is noted for its ergonomic and classic design. The LID-20c camera has the exclusive Hasselblad Natural Color Solution (HNCS) technology, which allows users to shoot breathtaking 20-megapixel photographs with amazing color detail. As a result, the UAV photographs provide a very clear view of the research region. This is critical in order for monitors to effectively monitor the research area without encountering issues that necessitate them to physically visit the study region. [5]

1.2 Building Inspection

Building maintenance is the process of repairing a building's structure and components. This is a common problem that must be carefully addressed to keep a building in good condition for a long time. Building performance evaluation is becoming more prevalent in Malaysian construction. [3] A part of evaluation that supports the main goal is examination. Wordworth (2001) defined inspection as a method to assess a product or service's ability to meet a predetermined standard. A skilled inspector or contractor will thoroughly inspect the building as part of a building inspection. The primary system frequently includes coverage for the foundation, plumbing, electrical, roofing, heating, and air conditioning. Because they are certified in one or more categories, specialised contractors or inspectors are typically qualified to make a professional determination on whether a facility complies with building code requirements. To keep a building's structural integrity for many years, facility inspections are crucial. Ensure that the structure conforms with the requirements of the building code.

1.3 Jabatan Kerja Raya Standard (JKR Standard)

The related maintenance standard must be used to analyze each defect thoroughly and classify it. Civil engineering projects have employed a variety of building inspection approaches. Malaysia does, however, employ a few inspection methods for facilities that the government has planned and built using methods that are typically employed by the public works department. To determine the kind and scope of damage, the JKR technique was created. The status of the harm is initially seen while utilizing this method, followed by the action of the damage that needs to be rectified. You can refer to these two elements in Tables 1. When the total matrix has been determined by multiplying the values from Tables 1 in Table 2, the colour of the damage should be determined based on the quantity. After gathering all forms and degrees of damage, the inspected building's status is determined as illustrated in Table 3.

Table 1 *Physical Condition Levels of Building Components [6]*

Multidisciplinary Applied Research and Innovation Vol. 5 No. 3 (2024) p. 23-32

Grade	Inspection Scale	Summary	Description
1	Very good	SB	• No defects • Excellent condition • Works well
2	Good	B	• No defects • Excellent condition • Works well
3	Average	S	• There is a defect or major damage. • Simple condition • Still work but needs to be monitored
4	Critical	K	• Critical situation • Cannot work accordingly service level agreed
5	Very critical	SK	• Very critical • Not functioning • Risk at all possible cause an accident or injury

Maintenance Action Priorities Level [6]

Priority	Scale Rating	Summary	Description
Normal	1	N	• No defect • No repair needed
Routine	2	R	• Minor damage • Needs to be monitored and repaired
Repair	3	PB	• Major damage • Need major repair
Recovery	4	PM	• Serious damage • Need for a repair urgent
Replacement	5	PG	• Damage • Urgent repairs • Needs detailed inspection

Table 2 *Phase Matrix Physical Condition Analysis of Building Components and Maintenance Action Priority Level [6]*

Scale		Maintenance Action Priority Level				
		5	4	3	2	1
The Physical State Building Component	5	25	20	15	10	5
	4	20	16	12	8	4
	3	15	12	9	6	3
	2	10	8	6	4	2
	1	5	4	3	2	1

Table 3 *Classification of Building Ratings (JKR 21602-0004-13,2013) [6]*

Rating	Condition	Action Matrix	Score
A	Very good	Scheduled	1 TO 5
B	Good	Condition-based Maintenance	6 TO 10
C	Average	Repair	11 TO 15
D	Critical	Recovery	16 TO 20
E	Very critical	Replacement	21 TO 25

2. Methodology

2.1 Data collection

This study is a physical study since it employs a field research technique. Several works have been planned to be carried out throughout this investigation to meet the objectives of this study. During the data collection process, among the activities carried out is capturing pictures using drones in high places and telephones in low places. Among the places that are included in the data collection are the front, right back, left and inside the hall. In addition, among the tools used in this process are staff and measuring tapes to measure damage.

2.2 Data processing

In the data processing part, among the images processed is the image of the roof. The image of the roof was taken using the Mavic 2 pro drone. This is because the roof is a part that is difficult to see with the naked eye. In this process, the roof image taken using a drone was combined using the Pix 4D mapper software. The result is that all parts of the roof taken using a drone are more complete and clearer.

3. Result and Discussion

Fig. 2 depicts the location of SMK Bandar Maharani Hall from the front, back, left, right, inside, and roof, as captured by an unmanned aerial vehicle (UAV). The location of the damage identified in each of the hall building's structures is indicated on each diagram with a red mark. Plan diagrams were also captured with a drone and edited with Pix4D Mapper. Prior to being granted an assessment level in accordance with the requirements of the Malaysian Public Works Department, as stated in Table 4, all damage is first assessed in terms of position, type, and cause.

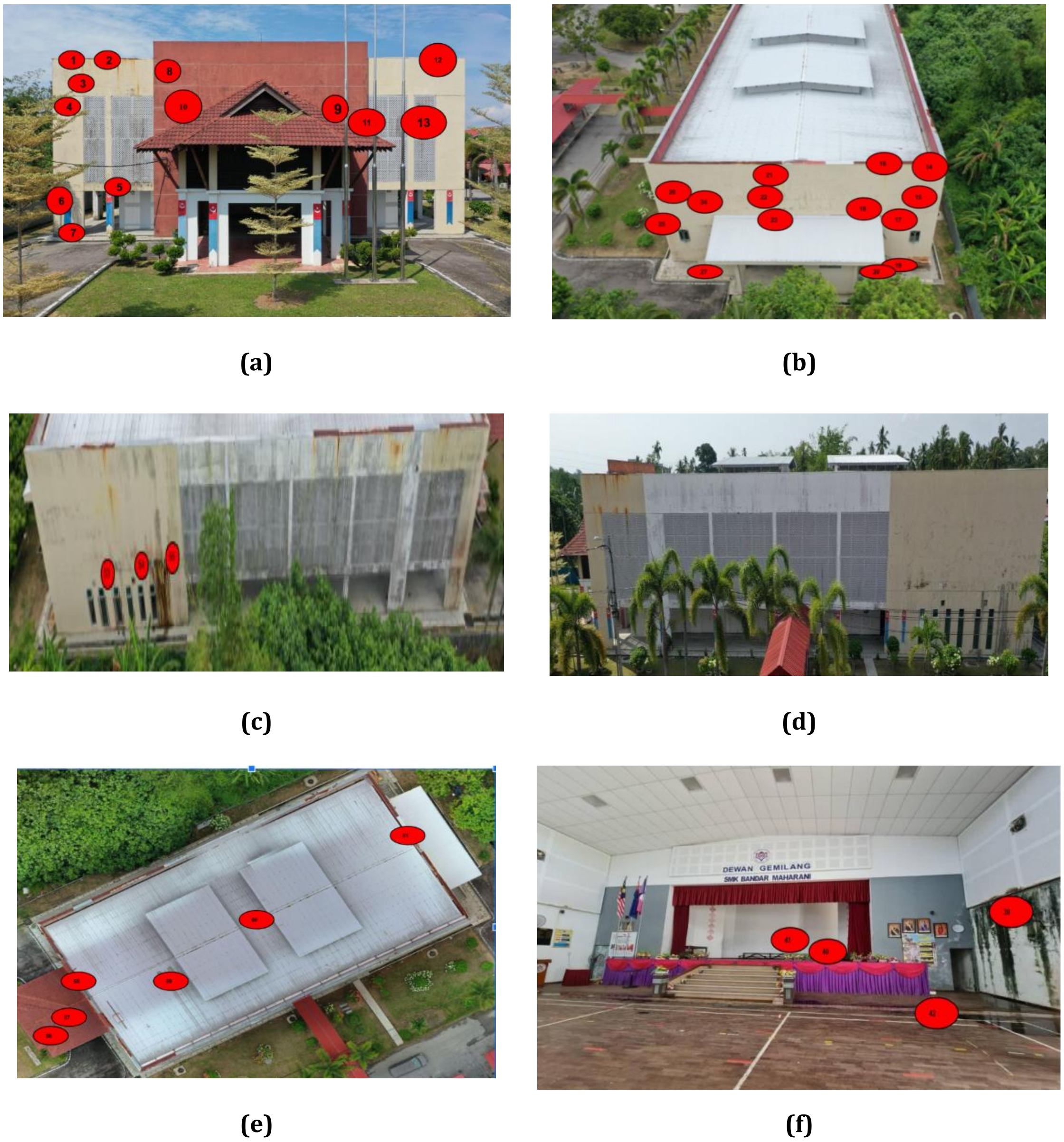


Fig. 2 *Damaged positions are indicated by red circles with numbers (a) Front view of the hall; (b) Rear view of the hall; (c) Left side view of the hall; (d) Right side view of the hall; (e) Plan view of the hall; (f) Interior view of the hall.*

After each damage is registered and examined to gauge the building's state, the overall damage level is computed. The building's overall score will be used for evaluation in accordance with the chosen methodology. The total score from the Malaysian Public Works Department is used to create an overall rating framework, with categories for excellent (green), good (blue), moderate (grey), critical (yellow), and highly critical (red). Table 3 displays an illustration of damage analysis. Table 4 provides a more thorough illustration of the damage to each component of the SMK Bandar Maharani hall's building structure.

In order to demonstrate how to determine the level of damage as well as the colour class in more detail, position 39 is used as an example. Table 1 is also used to determine the value of the priority level of the study building maintenance action. Table 1 is used to provide the value of the building condition score. To obtain the matrix referred to in Table 2, the results of the values acquired must be multiplied. The colour of the damage should be chosen based on the amount once the complete matrix has been obtained. The final step is to determine the status of the structure investigated as shown in Table 3 after gathering all sorts of damage and their levels.

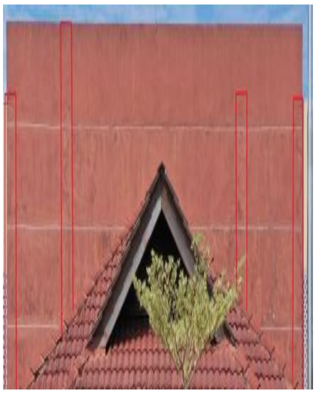
Table 4 *Example of analysis of defects at SMK Bandar Maharani*

Details of Defect	Figure of Defect

No of defect : 8

Condition	Priority	Matrix	Colour
3	3		

Location: The front centre of the hall
Level: Top
Element / component: Outer column wall
Defect description: Medium size of column crack
Possible cause: Penetration of moisture
Remarks: Weakening of building structure
Area: 2.779 m^2




No of defect : 22

Condition	Priority	Matrix	Colour
4	2	8	

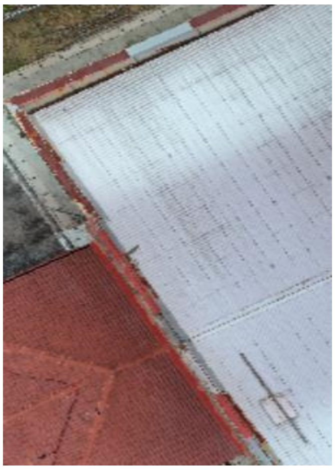
Location: Behind the central hall
Level: Middle
Element / component: Outer wall
Defect description: Large size of crack
Possible cause: The penetration of moisture through the opening
Remarks: Weakening of concrete structure
Area: 77.976m^2


No of defect : 53

Condition	Priority	Matrix	Colour
5	5	25	

Location: Bottom left of the left side Level: Bottom
Element / component: Outer wall
Defect description: Broken windows
Possible cause: Thermal stress
Remarks: Poor installation
Area: 1.509m^2 (each window)


Table 4 *Continue*

<table>
<tr><th>Details of Defect</th><th>Figure of Defect</th></tr>
<tr><td>No of defect: 46
<table><tr><td>Condition</td><td>Priority</td><td>Matrix</td><td>Colour</td></tr><tr><td>5</td><td>5</td><td>25</td><td></td></tr></table>
Location: Bottom right of the right side
Level: Medium
Element / component: Window
Defect description: Broken windows
Possible cause : Thermal stress
Remarks: Poor installation
Area: 1.172 (each window)</td><td> </td></tr>
<tr><td>No of defect : 58
<table><tr><td>Condition</td><td>Priority</td><td>Matrix</td><td>Colour</td></tr><tr><td>4</td><td>3</td><td>12</td><td></td></tr></table>
Location: Hall roof
Level: Top
Element / component: Roof
Defect description: Large area of rust
Possible cause: Water exposure over an extended amount of time, dirt and debris build up.
Remarks: Clogs of debris and leaves can cause rust
Area: 37.411 m^2</td><td> </td></tr>
<tr><td>No of defect: 39
<table><tr><td>Condition</td><td>Priority</td><td>Matrix</td><td>Colour</td></tr><tr><td>3</td><td>4</td><td>12</td><td></td></tr></table>
Location: Inside hall
Level: Middle
Element / component: Inside wall
Defect description: Large size of moss and mould
Possible cause: Dampness because of leaking roof and pipe
Remarks: Cause cracking and trigger health
Area: 10.796 m2</td><td> </td></tr>
</table>

On each side of the building structure, a total of 61 flaws and damages have been discovered at Table 5. The JKR Standard method was used to analyse all the data and information, which has been collected and displayed in the table. The building section may be used to classify the type and quantity of flaws. The sorts of damage involved are roof peeling, moss growth, and wall fissures. The overall score of 8.38 indicates that SMK Bandar Maharani is in good condition, but it must be addressed carefully in the crucial areas.

Table 5 *Schedule of Building Condition*

No	Location	Area m2	Defects	Condition Assessment (a)	Priority Assessment (b)	Metric (a) × (b)
1	Front View of the Hall (PH)	0.034	Flaking Roof	3	2	6
2		1.667	Water Seepage	3	2	6
3		3.703	Crack	3	2	6
4		2.077	Crack	3	2	6
5		0.653	Moss Growth	2	2	4
6		6.009	Crack	3	2	6
7		0.478	Tree Overhang	3	2	6
8		2.779	Column Crack	3	3	9
9		0.402	Chipped Paint	2	2	4
10		2.035	Crack	3	2	6
11		0.014	Crack	3	2	6
12		0.006	Spalling	3	3	9
13		0.076	Moss Growth	2	2	4
14	Rear View of the Hall	0.464	Flaking Roof	3	2	6
15		40.705	Crack	3	2	6
16		2.779	Water Seepage	3	2	6
17		45.767	Moss Growth	2	2	4
18		0.650	Moss	3	2	6
19		7.012	Crack	3	2	6
20		3.959	Moss	3	2	6
21		7.645	Water Seepage	3	2	6
22		77.976	Crack	4	2	8
23		5.062	Moss	3	2	6
24		44.886	Crack	3	2	6
25		0.139	Water Seepage	3	2	6
26		0.481	Moss	3	2	6
27		2.753	Crack	3	2	6
28		0.193	Crack	3	2	6
29	View in The Hall	12.612	Moss Growth	3	4	12
30		7.244	Moss	3	4	12
31		1.914	Crack	3	2	6
32		1.245	Crack	3	2	6
33		0.656	Mould	3	2	6
34		0.592	Mould	3	2	6
35		0.871	Moss and Mould	3	2	6
36		0.871	Moss and Mould	2	2	4
37		0.912	Perforated Roof	5	4	20
38		0.161	Perforated Roof	5	4	20
39		10.796	Moss and Mould	3	4	12
40		0.369	Perforated Wall	3	4	12
41		0.275	Crack	3	2	6
42		6.808	Ripped Out Floor	3	4	12

Table 5 *Continue*

No	Location	Area m2	Defects	Condition Assessment (a)	Priority Assessment (b)	Metric (a) × (b)
43	The Right-Side View of the Hall	1.078	Crack	2	2	4
44		5.197	Crack and Mould	3	2	6
45		3.173	Crack	3	2	6
46		1.172 (each window)	Broken Windows	5	5	25
47		3.594	Crack and Mould	3	2	6
48		6.178	Crack and Mould	3	2	6
49		1.413	Mould	4	4	16
50		10.984	Mould	4	4	16
51		0.491	Mould and Crack	3	2	6
52		0.223	Tree Overhang and Crack	2	2	4
53	The Left-Side View of the Hall	1.509 (each window)	Broken Windows	5	5	25
54		1.509 (each window)	Broken Windows	5	5	25
55		4.408	Moss	4	4	16
56	Plan View of the Hall	0.144	Hole	2	2	4
57		0.939	Hole	2	2	4
58		37.411	Rust	4	3	12
59		0.109	Hole	2	2	4
60		20.276	Rust	3	2	6
61		39.679	Rust	4	3	12
			Total Marks (d) {∑ of c}			511
			Number of defects (e)			61
			Total Scores (d)/(e)			8.38 > 5
			Overall Building Rating			Good

4. Conclusion

In conclusion, the aim of this study was to assess how well UAVs function in obtaining data and delivering information on errors in creating and developing 3D models by converting image data using specialized photogrammetric modeling software has achieved. The following statements show the objectives have been fulfilled. First, the Orto mosaic image and digital surface model (DSM) was produced by using Pix4D Mapper software. The Public Works Department (JKR) and an unmanned aerial vehicle (UAV) were used to classify the problem on the plan, sides, and interior views. Among the items that may be classified from the photograph are the sort of damage itself, such as cracking, mold growth, and shattered windows. Aside from that, the source and consequence of the harm have been determined. The damage area on each of the scratches may then be computed using Image J software. Lastly, the index of defect and kind of defect were assessed using the Public Works Department (JKR) visual inspection procedure. The statistics show a total of defect are 61 errors with a total score of 8.38 and a total mark of 511.

According to the research findings, the building was in good condition, classified as blue in color, and maintenance based on condition is required. However, it still requires attention and management to keep the illness from deteriorating. These findings indicate that the employment of UAV unmanned aircraft can become a viable alternative to building exterior structural examination. These findings have significant implications for delivering knowledge prior to conservation building without requiring many people. In addition, building inspection utilizing UAVs will assist in cutting operating costs, saving time, and making the user more pleasant. This kind of building inspection improves the building's monitoring system. Damage to the building can be identified early, and regular inspections of the building are possible. Furthermore, picture processing and analysis will highlight the flaw in-depth as well as the severity of the issue for the building.

Acknowledgement

The authors would like to thank the Centre for Diploma Studies (CeDS), Universiti Tun Hussein Onn Malaysia for their support.

Conflict of Interest

There is no conflict of interest with this paper, as it was identified by the authors.

Author Contribution

The authors have contributed to this past of the paper as follows: **study conception and design:** Nor Shuhada Natasha Rosli, Nur Adlin Sabrina Mohd Akbar, Nurul Qamarina Kamarolzaman; **data collection:** Nor Shuhada Natasha rosli, Nur Adlin Sabrina Mohd Akbar; **analysis and interpretation of results:** Nor Shuhada Natasha Rosli, Nur Adlin Sabrina Mohd Akbar, Nurul Qamarina Kamarolzaman; **draft manuscript preparation:** Nor Shuhada Natasha, Nur Adlin Sabrina Mohd Akhbar, Nurul Qamarina Kamarolzaman. All authors reviewed the results and approved the final version of the manuscript.

References

[1] M. Kaamin, N. A. Aziz, S. Mohd, Z. A. Bukari, N. Samion, A. Abd Kadir & N. Ngadiman. "Kaedah pemeriksaan bangunan tinggi menggunakan pesawat tanpa pemandu (UAV)," Jurnal Teknologi, vol. 78, no. 5-10, May, 2016. [Online serial]. Available: https://doi.org/10.11113/jt.v78.8839. [Accessed September 15, 2024].

[2] N. Hamzah, M. Mahli, A.I. Che Ani, M. Tahir, N. Abdullah & N. Tawil, "The development of smart school condition assessment based on condition survey protocol (CSP) 1 matrix: A literature review," Science, Engineering and Technology, vol. 23, no. 620-5, Nov, 2010. [Online serial]. Available: http://scholar.waset.org/1999.3/12567. [Accessed September 15, 2024].

[3] M.H. Hanafi, M.U. Umar, A.A. Razak, Z.Z. Rashid, N.Z. Noriman & O.S. Dahham, "Common defect of colonial buildings in Malaysia," In IOP Conference Series: Materials Science and Engineering, vol. 454, no. 1, December, 2018. [Online serial]. Available: https://doi.org/10.1088/1757-899X/454/1/012186. [Accessed September 15, 2024].

[4] Google Earth version. (2023). SMK Bandar Maharani Muar. Coordinates,Eyealt' .https://earth.google.com/web/@3.06053111,106.57771054,-504.25749142a,2255286.85814202d,35y,0h,0t,0r/data=CkoaSBJCCiQweDMwMzRkMzk3NWY2NzMwYWY6MHg3NDU5NjkzMjgyMTFjZDgZN1MhHonXEEAhHqM883J-WUAqCE1hbGF5c2lhGAIgAToDCgEw. [Accessed on 17 December 2023]

[5] Y. Zhou, M. Daakir, E. Rupnik & M. Pierrot-Deseilligny, "A two-step approach for the correction of rolling shutter distortion in UAV photogrammetry," ISPRS Journal of Photogrammetry and Remote Sensing, vol. 160, no. 51-66, Feb, 2020. [Online serial]. Available:https://www.sciencedirect.com/science/article/abs/pii/S0924271619302849. [Accessed on 17 December 2023]

[6] JKR, Garis Panduan Pemeriksaan Dan Penilaian Keadaan Bangunan Sedia Ada (JKR 21602 -0004 -13), JKR 21602-. Bahagian Senggara Fasiliti Bangunan, Cawangan Kejuruteraan Senggara Ibu Pejabat JKR Malaysia, 2013.

[7] M. Hassanalian, D. Rice & A. Abdelkefi, "Evolution of space drones for planetary exploration: A review," Progress in Aerospace Sciences, vol. 1, no.97, Feb, 2018 [Online serial]. Available: https://doi.org/10.1016/j.paerosci.2018.01.003 [Accessed on 17 December 2023]