Realtime monitoring study for highway construction using Unmanned Aerial Vehicle (UAV) technology

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Abstract. Monitoring is an important part of project management with the aim of knowing how far the project is running and whether there are obstacles during the project's running. At present, this monitoring process cannot be done in real-time, and conventional monitoring tends to be expensive and error prone. Unmanned Aerial Vehicle (UAV) is a technology that began to be developed to overcome these problems. The research discussed the use of UAVs for real-time monitoring, with quantitative and qualitative methodologies using primary and secondary data. The results of the research indicate that: (1) UAVs produce 3D photogrammetric that provide more detailed and easier results in real time monitoring, (2) The use of UAV is 35.41% faster, accuracy reaches 71.22%, more economical up to 78%, productivity level of up to 94.48% compared to conventional methods, (3) Limitation of UAV capability in conducting real-time monitoring, including battery power, and not yet waterproof.

Keywords: real-time monitoring, highway construction, UAV technology

1. Introduction
Monitoring is an important part of the project management information system. The purpose of monitoring is to find out how far the project is going and whether there are obstacles during the project's progress. The problem that still becomes an obstacle in monitoring construction is to document changes that occur in the field and to prepare the schedule that has been built. In current practice, deviations from planned performance can only be reported after significant time has passed, and manual monitoring of construction activities is expensive and error-prone.

Along with recent technological advances, the use of Unmanned Aerial Vehicles (UAVs) continues to increase in various fields including construction, where planning and monitoring of construction activities is one of the main areas where UAVs can significantly improve performance and speed. Unmanned Aerial Vehicle (UAV) systems as a data acquisition platform and as a measurement instrument are becoming attractive for many surveying applications in civil engineering [1]. UAV technology can be efficiently used dynamically to produce more practical and cost-effective operations in the field of construction management and monitoring and this UAV system not only provides an easy and smart way for site supervision and management but also results in better operations, planning and effective on-site adjustments [2]. Furthermore, the conventional application of certain survey applications still has several obstacles including depending on the terrain, being limited in range, very complex and expensive, having high measurement errors, and / or taking longer. These approaches can
be overcome with UAVs if UAV technology is proven to be accurate and reliable, eventually assisted or replaced for certain segments in survey applications. The use of UAV is an alternative method in conducting surveys in the future, the use of UAVs can provide practical value because it is faster in its use, the use of UAVs is faster in conducting data acquisition because of the cloud point [3]. Unmanned Ariel Vehicles (UAVs) or drones can be used as a part of Automatic Data Collection (ADC) system to provide real-time information in transportation and construction disciplines [4].

UAV has been used in different purposes in the context of construction, such as the monitoring and maintenance of pavements and highways, checking and monitoring of bridges; checking buildings, monitoring of damages and cracking, maintenance of facades and mapping of historical monuments, as well as 3D modeling for reconstruction of buildings, photogrammetric applications such as volume measurement using digital terrain model [5].

The research provides the latest updates on the application of UAV technology in its application to the construction world, especially in monitoring the achievement of work on road construction landfills and other applications that can be done by monitoring work using this UAV technology.

In accordance with the problems and previous studies, it was found that some formulations of problems that became the reference in the research included how to conduct a real time monitoring with a short time with the right results and low cost, the use of this UAV can overcome these challenges and how fast are their abilities, and what about the level of productivity when compared with methods that had been running before (conventional methods). Therefore, the objectives of the research are also obtained, among others, producing new output data in the form of 3D photogrammetry in real time, analyzing the comparison of time, accuracy, cost, and productivity with conventional methods, and analyzing the limits of the ability to use this UAV technology in conducting real-time monitoring.

2. Methodology

2.1. Research stages

The method of the research is a quantitative research to comparation between collecting data using manual and UAV. The variable of comparation can be seen in Table 1 and Figure 1.

| Variable  | Unit     |
|-----------|----------|
| Time      | sec      |
| Accurate  | %        |
| Cost      | Rp       |
| Productivity | m²/person/day |
2.2. Data collection
The two stages for collecting data, from field and contractor. The mechanism for collecting data is observation quantitative. Data source is the contractor of the Cileunyi – Sumedang – Dawuan Highway project. The location can be seen in Figure 2.
Primary data use UAV technology in the highway construction project area directly. The secondary data come from the progress data of the toll road and bridge construction project work that become the research site. Most of the data obtained are quantitative and there are some qualitative data obtained during the observation and research process. The equipment for the research can be seen in Figure 3. The type of UAV is Quadcopter.
3. Result and discussion

3.1 Data processing results

Based on data processing performed on the two methods, the results show that the use of conventional methods with a total station only produces measurement data in the form of point data that can only be processed with 2D drawing plans. Unlike the UAV method which produces measurement data in the form of dots and images, so that the data processing can produce 3D images. Comparison of data processing results of these two methods can be seen in Figure 4.

![Comparison of Data Processing Results](image)

Figure 4. Comparison of Data Processing Results

With the results of the comparison of these two methods it can be said that the use of the UAV method produces better data in conducting real time monitoring as presented in previous studies that the use of UAV produces 3D modeling that makes it easy to identify project status [4]. The results of this 3D modeling also have several other advantages such as the following:

- facilitate the delivery of information, so that it is very easy if integrated with the BIM work method.
- avoiding mistakes when reading images.
- they can be understood by experts and laypersons, making it easier for certain parties such as the project owner to know the achievements of the work on the project in real time.

3.2 Time comparison

Based on observations and research that has been carried out on both methods between conventional methods and the UAV method in real time monitoring work, which in the research takes a case study on the monitoring work on hoarding soil. The following data can be seen in Table 2 and Figure 5.
Based on the analysis results shown in Table 2 and the graph shown in Figure 3, these results are in line with the results of previous studies. This UAV can retrieve data in the form of aerial images with a large scope and scale in a short time.

3.3 Accuracy
To get accuracy it is done by comparing the results of the calculation of the resulting volume, and the UAV method is compared with the conventional method. The results are presented in Table 3 and Figure 6.

Table 3. UAV Accuracy

| No | Process                                   | Unit | Conventional (m³) | UAV method (m³) |
|----|-------------------------------------------|------|-------------------|----------------|
| 1  | Data Collection                           | second | 7.062,11          | 390            |
| 2  | Data Transfer                             | second | 1.849,19          | 900            |
| 3  | Data Processing                           | second | 16.642,69         | 17.760         |
| 4  | Volume calculation                        | second | 11.095,13         | 450            |
|    | **Total**                                 |       | **29.587,01**    | **19.110**     |

Figure 5. Graph Comparison of Data Collection Process Time
Based on these results obtained from the UAV, the results of a calculation of a larger volume of about 4% by measurement with a total station in the conventional method, but the results of the closeness of accuracy with a total station is quite large. This result is supported by previous research that the UAV method is a method that facilitates the work of monitoring and maintaining its accuracy value.

3.4 Cost comparison
Based on observations and research that has been carried out on both methods between conventional methods and the method of Unmanned Aerial Vehicle (UAV) in real-time monitoring work, which in this study took a case study on the monitoring work on hoarding soil. Obtained the costs needed to procure the tools needed for both methods in Table 4.

| Table 4. Cost Comparison |
|--------------------------|
| Cost               | Total Cost (Rp)  |
|----------------------|-----------------|
| Conventional         |                 |
| Capital             | 89,071,692      |
| Operational         | 2,391,484,208   |
| UAV                 |                 |
| Capital             | 85,245,747      |
| Operational         | 628,743,659     |

Based on the data shown in Table 4, it is found that the results that the overall costs required by the UAV method have lower costs compared to conventional methods. The use of UAVs can save costs up to 71.22% of the costs used in conventional methods as shown in Figure 6. The results obtained provide a consistent assessment that the use of this UAV method results in more practical and cost-effective operations in the field of construction management and monitoring. The result of the difference which is quite far adrift is also due to the large operational costs due to the reduced amount of resources if using the UAV method so that it can reduce the operational number is lower.

3.5 Productivity
Based on observations and research that have been carried out on both methods between conventional methods and the method of Unmanned Aerial Vehicle (UAV) in real-time monitoring work, where in the research takes case studies on the monitoring work on hoarding, the obtained level of productivity of both methods can be seen in Table 6 and graph in Figure 7.
Table 5. Productivity

| Time (seconds) | Work Area (m²) | Productivity (m²/sec) |
|----------------|----------------|-----------------------|
| Conventional   | 2.291,42       | 14.934,88             | 6.52                  |
| UAV            | 390            | 46.029                | 118.02                |

Based on the results of the comparison of the data shown in Table 4 and the graph in Figure 7, the productivity level of using UAV technology has higher results compared to conventional methods, where the UAV method results in an increase of up to 94.48% of the level of productivity compared to conventional methods. These results provide harmonious results delivered which says the use of UAVs in building projects can provide a better level of productivity, and in this study also produces the same opinion if the UAV method is applied to road construction projects.

3.6 UAV limitation
The results obtained in the research are not only about the advantages obtained or the positive value generated in this UAV method, but also obtained the ability limit on the UAV method in the process of observation and ongoing research. The limitations of the ability of this UAV method include the following:

- The UAV method pay attention to the ideal flying height and requires a good camera resolution because the flight height affects the UAV in producing optimal monitoring image results.
- The UAV method is very dependent on the ability of the battery power on the UAV device which usually does not have a long ability endurance, so it requires a backup battery in the process of use.
- The UAV method cannot be done in rainy weather, because the UAV device does not yet have the capability of water resistance so it needs to be ensured when the real-time monitoring process has to be carried out in sunny weather and a work area that is safe from water.
- Accuracy results on the tools used in the research are not accurate up to 100% with conventional data, so it is necessary to do final verification with the help of conventional methods with certain periods such as each semester, one year, or at the end of the project.

3.7 Other implementation of UAV in project real-time monitoring
In addition to conducting real-time monitoring of work achievements as in the research which takes case studies on landfill work on toll road works, there are also other real-time monitoring functions that can be carried out with the help of UAV technology. Work Method Planning and Calculation of Material...
Availability Period (Land Stockpile). Simulation and analysis results based on UAV output data are shown in Figure 8, Figure 9, and Table 6.

![Figure 8. Zoning Work Simulation 1](image1)

![Figure 9. Zoning Work Simulation 2](image2)

| Simulation | Land Volume Required (m³) | Remaining Stockpile Volume (m³) | Work Hours |
|------------|---------------------------|---------------------------------|------------|
| 1          | 7.108,170                 | 292,930                         | 32,880     |
| 2          | 5.686,530                 | 1.714,570                       | 32,900     |

4. Conclusions
Based on the result and analysis, it can be concluded that monitoring project using UAV:
- UAVs produce 3D photogrammetric that provide more detailed and easier results in real time monitoring. Because of the quality of image is very important for monitoring project, the future study can be added about 3D photogrammetric capability.
- UAV is 35.41% faster, accuracy reaches 71.22%, more economical up to 78%, productivity level of up to 94.48% compared to conventional methods.
- Limitation of UAV capability in conducting real-time monitoring, including battery power, and not yet waterproof.

References
[1] Siebert S, Teizer, and Jochen. 2014. Mobile 3D mapping for surveying earthwork project using Unmanned Aerial Vehicles (UAV) system. Automation in Construction Journal. 41 1-14.
[2] Anwar N, Izhar M A, and Najam F A 2018 Construction Monitoring and Reporting using Drones and Unmanned Aerial Vehicles (UAVs). The Tenth International Conference on Construction in the 21st Century (CITC-10).
[3] Brinker R C, Wolf P R, and Walijatun D 2000 Dasar-Dasar Pengukuran Tanah (Surveying). Jakarta: Erlangga.
[4] Srewil Y 2015 Feasibility of Use UAVs (Drones) in Construction, Technical Report, Technische Universitat Dresden.
[5] Dastgheibifard S, and Asnafi M 2018 A Review on Potential Applications of Unmanned Aerial Vehicle for Construction Industry Sustainable Structure and Materials 1 44-43.