

Comparison of Digital Terrain Model Elevation Aerial Photography with Terrestrial Measurements in Oil and Gas Exploration Well Areas

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ABSTRACT

Accurate elevation determination is one of the crucial aspects in oil and gas exploration activities, especially in the planning and management of well areas. This study aims to identify and compare elevations. The Digital Terrain Model (DTM) was created from aerial photographs and terrestrial data by converting Digital Surface Model (DSM) information to DTM. The urgency of this research is driven by the need for accurate, efficient, and economical mapping methods, as well as validation of the methods used in topographic mapping. Digital Terrain Model (DTM) is a virtual model that adds elements such as fault lines and observations to correct artefacts from the original data, while DSM includes the height of all objects on the ground surface. The results of the study showed that the largest elevation value in the aerial photo DTM was 14.416 meters at point L06, and the smallest elevation value was 6.567 meters at point A46, with an average elevation of 13.716 meters. Meanwhile, the results of the comparison of the elevation of the aerial photo DTM with terrestrial measurements showed the largest difference of 5.513 meters at point A46 and the smallest difference of -2.682 meters at point L21, with an average difference of 0.072 meters. The vertical accuracy level (Z) based on the LE90 value is 0.2076 meters, which meets the geometric accuracy standard of 1:1000 scale class 1 according to BIG Regulation Number 15 of 2014. A 3D model of the DTM elevation of aerial photography also supports the results of this comparison. This study makes an important contribution to the validation and improvement of aerial photography-based topographic mapping methods, while also providing an overview of the accuracy of the resulting data.

Keywords: Digital Terrain Model (DTM), Global Navigation Satellite System (GNSS), Oil and Gas Exploration, Terrestrial Measurement, Digital Surface Model (DSM)

1. Introduction

The use of aerial photography and image processing technology has brought significant efficiency and effectiveness to mapping. Digital Terrain Models (DTM) generated from aerial photography can cover a wider area quickly and efficiently compared to terrestrial measurements, which require more time and effort. By researching to validate the accuracy of DTM elevations from aerial photography against terrestrial measurements, we can ensure that this faster and more economical mapping method provides accurate results [1].

Three main types of data are obtained through aerial imagery captured by UAVs: orthophotography maps, digital surface models (DSMs), and contour data. Digital Terrain Models (DTMs) are usually derived from land mapping and manual stereo mapping using conventional methods to produce precise contour lines. In this case,



DTMs are the basic elements of mapping, so you need to find a way to create them quickly and efficiently. We need to know how accurately DTMs represent the earth's surface so that we can consider their accuracy when using DTMs [2, 3].

A digital terrain model (DTM) is a virtual model that adds elements such as fault lines and observations to the original data to correct for artefacts created using only the original data collected at the total station [5]. While a DTM shows only the ground (the floor surface with no elements above it), a DSM shows any surface features that exist [6]. The heights of trees, buildings, and all objects on the ground surface are captured in aerial photographs [7].

This study aims to output the results of aerial photography by UAV to DEM and use it as a reference to create a topographic map. As the DEM data generated by UAV acquisition is based on Surface or DSM, which is then filtered for bare earth using SAGA GIS software to make it DTM. Furthermore, a comparison of the DTM elevation value generated by the results of aerial photography with DTM terrestrial measurements through Arc-Gis for the creation of its topographic map. This type of research is quantitative, with a study of data collection.

2. Research Methodology

In this paper, quantitative analysis can be performed by comparing DTM visualisations from aerial photographs with terrestrial measurements to identify differences and similarities in topographic patterns. This can involve visual observation of surface shapes and contours, and significant elevation changes. The location of this research was conducted at one of the MJ-12A Drilling Locations with an area of ± 3.92 Ha located at the MJ-A12 Drilling Location in Beruge Village, Babat Toman District, Musi Banyuasin Regency, Ramba Field. The location of the mapping survey is a planned location of a directional well in the MJ structure located in the existing MJ-12A well area.

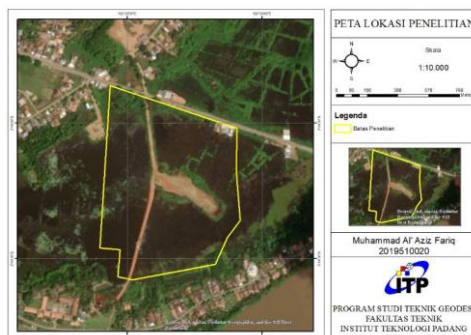


Figure 1. Research Location

The tools used in this research can be seen in **Table 1**. Otherwise, the data used for this study were photo data and ICP coordinate values obtained from data collection in the field, which can be seen in **Table 2**.

Table 1. Equipment used for research

Tool Name	Utility
Dell Inspiron 14 Laptop	Report creation and data processing
Microsoft Office	Data processing and report creation
Agisoft Methashape	Aerial photo processing
Arc-Gis	DTM Comparative Analysis and Layout Creation
Saga-Gis	Data processing filtering Aerial photo

Table 2. Data used for research

Data	Data type and year	Information
Geodetic Observation	Primery Data/ 2023	Data <i>Ground Control Point</i>
Terrestrial Measurements	Primery Data / 2023	Measurement Result Data
Aerial Photo	Primery Data / 2023	135 photo scene

Data collection is the collection of field data through direct measurements in the field and recording aerial image data with the DJI Phantom V 4 Pro 2.0 drone. GNSS measurement using static method is done by making new BM/Tugu points made from concrete cement casting around the mapping location, as many as 2 (two) points. The following is a table of reference coordinates for GNSS measurement. Topographic measurements were carried out after the BM monument was completed. Topographic measurements were carried out using the perfect bound closed polygon method. Topographic measurements were carried out for 1 month using a total station measuring instrument. Topographic measurement data processing was carried out in Microsoft Excel to produce elevation data in the format P, E, N, Z, D. From the results of topographic data processing, the highest elevation was obtained at 16,316 meters.

The initial stage carried out was to determine the location or survey area for taking aerial photos, namely the location of the MJ-12A well with an area of ± 3.92 ha. The creation of the flight path was carried out by importing polygons whose area had been determined into controller with kml format. Before flying flight plan made with the help of controller based on the kml polygon of the research area. Then set the flight height at a height of 100m and the flight duration for 27 minutes. Settings drone using the method overlaps with a side percentage of 80% and front 70%. The result is an orthophoto that has undergone geometric correction so that the image scale is uniform and follows a certain map projection. The resulting orthophoto visually appears high resolution and is color corrected creating a smooth and accurate representation of the area. Highly visible objects such as houses, roads, buildings, and swamps provide high accuracy and detailed information so that it can be used in various fields that require accurate spatial data. Products obtained from aerial photography other than Orthophoto, can also produce DEM and DSM which are obtained through processing using Agisoft Software. The resulting DEM is a three-dimensional representation of the earth's surface from height data on the surface of an area which can be seen clearly in Figure 3. It still shows the object above. land such as housing, roads, buildings, river flows and vegetation which are objects that are height.

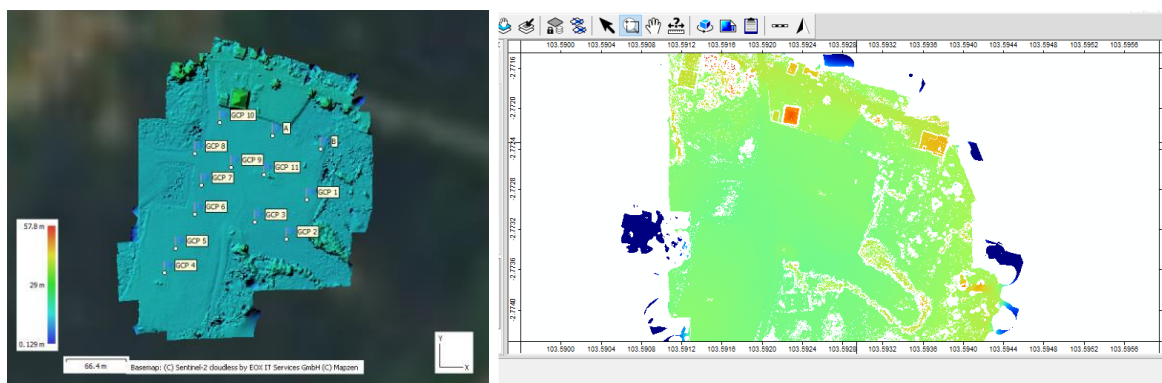


Figure 3. DEM and filtering process

The next stage is DEM filtering, which represents the shape of the earth's surface along with the features of the objects above it into a DTM which represents the elevation of the earth's surface without any objects such as buildings, vegetation or bridges. The DSM to DTM processing process (filtering) is carried out using the Saga Gis application. The DTM raster data resulting from the filtering process is then converted into points so that it can be interpolated into contour lines. After the data conversion process from raster data to vector, you can then see the results of the aerial photo elevation values in the raster value table in the attribute table. Comparative analysis of elevation values is carried out after the elevation values resulting from terrestrial measurements and aerial photographs are known so that the differences in elevation values can then be seen. At point K35 the elevation value resulting from terrestrial measurements is 14.36 meters. Meanwhile, the elevation value from aerial photography at the same point is 14.009, so the difference is 0.351 meters. Analysis was also carried out to determine vertical accuracy to determine the RMSEz value and calculate the LE90 value for the RBI map geometry.

3. Results and Discussion

The results of static data processing are in the form of coordinates that will be used for Benchmark observations and Ground Control Points as reference points for ICP measurements and aerial photography. The results of static data processing can be seen in Table 3. The results of the orthophotos were made using Agisoft Photoscan V.1.7.6 software with medium/medium texture quality can be seen in Figure 4. The photo data is 135 photos with a flight height of 68.7 m with 13 GCP control points. The total calculated area is approximately ± 3.92 ha.

The DEM data in this research is controlled data obtained from the results of field research which is then processed with Agisoft Photoscan V.1.7.6 software, which is used as data for making 3D river modeling.

Table 3. Static data processing results

GCP Name	UTM Coordinates (Meters)		Elevation (Meters)
	Northing	Easting	
A	9693465,723	343563,059	14,518
B	9693451,337	343615,089	14,612
GCP 1	9693395,952	343600,579	14,438
GCP 2	9693352,332	343578,002	13,75
GCP 3	9693371,325	343543,564	14,021
GCP 4	9693315,38	343444,623	14,673
GCP 5	9693342,579	343456,408	14,483
GCP 6	9693379,82	343477,479	14,145
GCP 7	9693411,498	343484,995	13,963
GCP 8	9693446,051	343477,215	13,912
GCP 9	9693431,252	343517,306	14,367
GCP 10	9693480,365	343504,813	14,171
GCP 11	9693423,019	343553,049	14,811

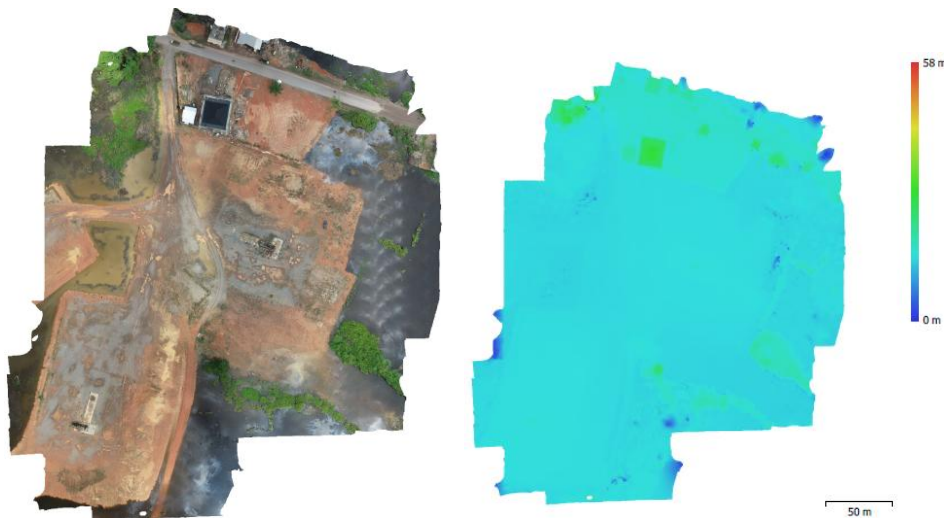


Figure 4. Orthophoto from Agisoft Photoscan to DEM

DSM data is obtained from the results of aerial photo processing carried out by filtering in the Saga GIS application. Filtering is a process or work step to obtain Digital Terrain Model data from Digital Surface Model data resulting from aerial photography that has been carried out. Researchers carried out the filtering process 4 times to get maximum results. The parameter choice used by researchers is the advance parameter, namely increasing the slope parameter so that it covers vegetation or buildings at the MJ-12A well location. Parameters with a kernel radius of 15 meters with a slope of 10% obtained the results of changing the Digital Surface Model of aerial photography into a Digital Terrain Model of aerial photography as shown in Figure 5 below.

The results of this filtering parameter aim to carry out filtering so that the elevation model produced from aerial photos which includes trees and buildings can be filtered to get elevation based on terrain for further analysis of the comparison of elevation values and distance values produced from the Digital Terrain Model of aerial photos with the measurement results terrestrial.

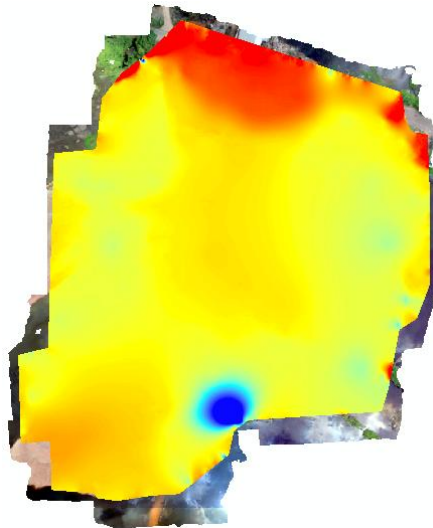


Figure 5. Digital Terrain Model UAV

The elevation comparison is used to carry out elevation comparison analysis between the elevation resulting from terrestrial measurements and the elevation resulting from DTM aerial photography. The following is an image of the comparison results based on the cross below.

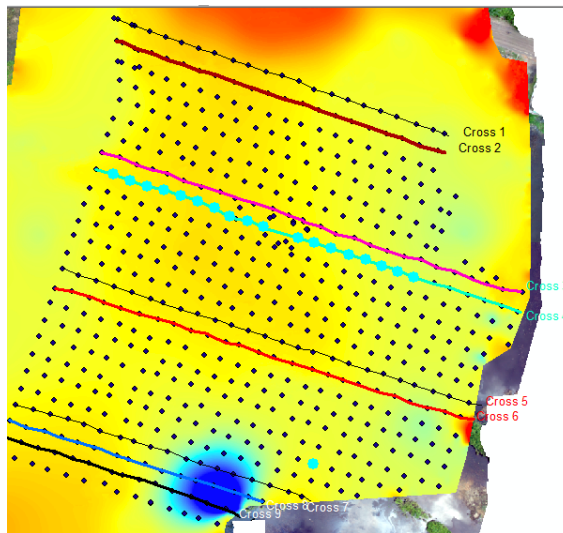


Figure 6. Cross Comparison

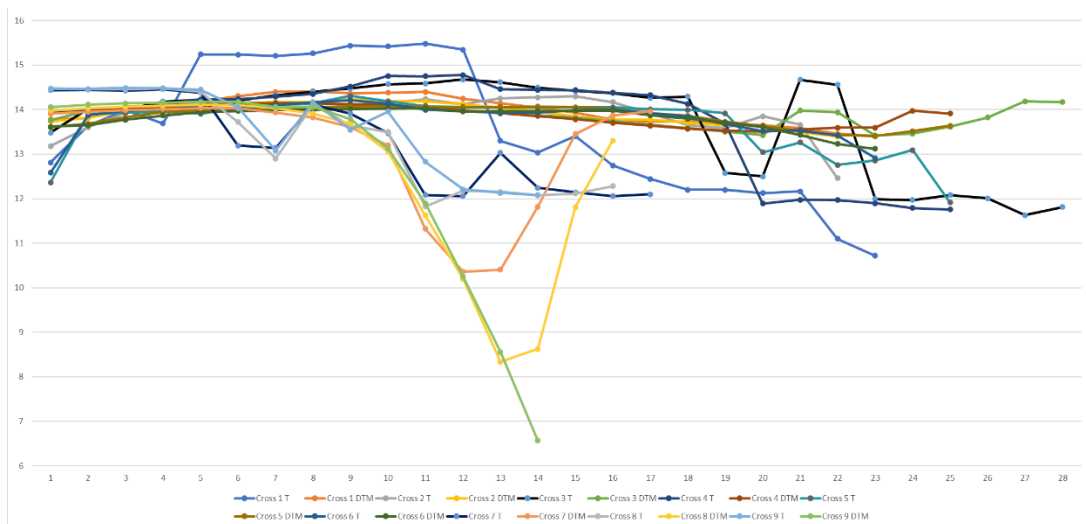


Figure 7. Cross Comparison Chart

At Cross 1 there are 23 points from each cross obtained from terrestrial measurements and also from elevation points from aerial photo DTM data showing that the comparison of the elevations obtained can be seen on the graph to have quite significant differences. Where the elevation at point four, namely point L10, at the terrestrial point, the elevation value is 15,345 meters, while the DTM aerial photo elevation value is 14,245 meters and produces a difference in elevation value of 1,100 meters.

Comparative analysis of RMSEz and LE90 is produced from the results of the elevation comparison between the elevation resulting from terrestrial measurements and the elevation resulting from DTM aerial photography. The number of points obtained by comparison was 610 sample points from 891 terrestrial measurement points. The results obtained are the value of the elevation difference between the height in the DTM aerial photo and the points in the Terrestrial Measurement and then calculating the average squared value of this difference. After that, the RMSEz value can be calculated by taking the square root of the average square value. By using the RMSEz value, the RBI geometric accuracy test classification is based on the standards in Perka BIG No. 15, 2014, which aims to see the accuracy of heights in DTM aerial photos as well as the resulting mapping scale categories. From the results of this RMSEz calculation, the RMSEz is 0.1258 meters.

The topographic map results were obtained from the DTM data processing process which had been filled in, using ArcGIS software. At the research location, namely the MJ-12A directional well, a topographic map was made based on the LE 90 results, namely Class 1 using a scale of 1:1,000. This means that 1 cm on the map is the same as 10 meters in the field and the minor contour interval is 0.4 meters and the major contour is 2 meters. The results of the topographic map can be seen in Figure 8 below.

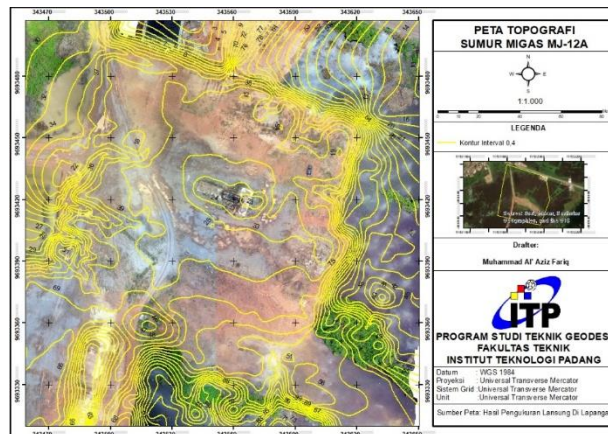


Figure 8. Topographic Map Result of Terrestrial Measurements

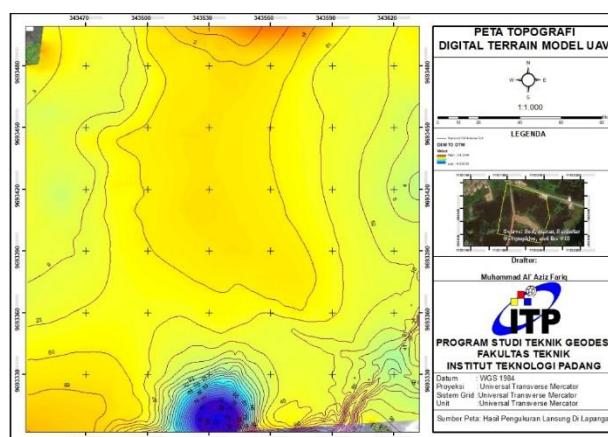


Figure 9. DTM Topographic Map Aerial Photo

The map above is the result of topographic measurements using terrestrial methods (direct measurements in the field). Contour lines are displayed at 0.4meter intervals, indicating elevation changes. The closer the contour lines, the steeper the slope in that area. The basic colors of the map show variations in the color of the land and surface being measured, with some lighter or darker areas to indicate geographic features, such as hills or valleys. There are crossing points that may indicate measurement points or observation stations during the survey.

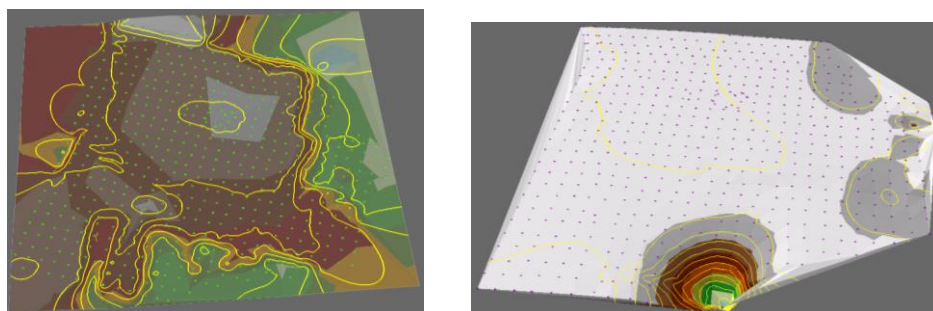


Figure 10. 3D Model Results from Terrestrial Measurements and DTM Aerial Photographs

The left image shows the results of topographic measurements using terrestrial methods, where elevation data is obtained through ground surveys. The visible contours show elevation differences resulting from direct measurements in the field, with different colors indicating different heights. Using this method usually provides more detailed data in areas that are measured directly, especially in areas that have difficulty-to-reach terrain.

Meanwhile, the right image is the result of topographic measurements using the Digital Terrain Model (DTM) obtained from an aerial survey. In this image, elevation differences are visible with smoother contours and a more uniform grid, indicating coverage of a wider area with the elevation data generated from the aerial scanning method. The largest elevation recorded on this map is 14,416 meters, while the smallest elevation is 6,567 meters. These elevation differences show significant elevation variations in the mapped area, providing important information for surface and land use analysis in the area.

4. Conclusions

From the results of identification and conversion of Digital Surface Model data into Digital Terrain Model Aerial Photos, the largest elevation value was obtained, namely 14,416 meters at L06 and the smallest elevation value was 6,567 meters at point A46, so the average elevation in the aerial photo DTM was 13,716 meters. The results of comparing the elevation of DTM aerial photos with terrestrial measurements showed that the largest elevation difference value was 5.513 meters at point A46 and the smallest elevation difference value was -2.682 meters at point L21, so the average difference in elevation value was -0.011 meters. The results of vertical accuracy or elevation (Z) are with a LE90 value of 0.2065 meters and have met geometric accuracy standards at a scale of 1:1000 class 1 based on BIG Regulation Number 15 of 2014. The comparison results can also be seen from the 3D model image produced from elevation Digital Terrain Model Aerial Photo.

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